VOLUME XLVII NUMBER 6

BOTANICAL GAZETTE

JUNE 1909

CONTRIBUTIONS FROM THE ROCKY MOUNTAIN HERBARIUM. VIII

AVEN NELSON

In 1905 Mr. LESLIE N. GOODDING again made some collections in the deserts of southern Nevada and adjacent Arizona. These plants, like those of his collections of 1902 and 1903, were deposited with the Rocky Mountain Herbarium at the University of Wyoming, to be named and distributed. Interesting as the earlier collections proved, these which came from even more inaccessible places and from regions which represent the extremes of aridity and heat are equally so. I submit herewith descriptions of the new species and notes upon others that are but little known or that seem to need generic differentiation.

PLANTAE GOODDINGIANAE

Calochortus comosus, n. sp.—Glabrous: bulb small, 8–12^{mm} in diameter, covered with dead sheathing flaky scales which also invest the base of stem: stem very slender, slightly flexuous, 1–2^{dm} high, 1 (rarely 2)-flowered: leaves narrowly linear: sepals lance-linear, as long as the petals: petals pale lavender or lilac, with darker lines, but not marked with spots or bands of other colors, broadly triangular-ovate, 18–25^{mm} long; the apex subtruncate, slightly undulate-dentate; the gland large, ovate, inordinately densely long-bearded with yellow hairs which are glandular-thickened toward the apex; similar hairs are scattered over all the lower half of the petal: anthers white, acute, 7–8^{mm} long; the filament as long: capsule acute-angled.

Las Vegas, Nevada, in limestone washes, May 8, 1905, *Goodding* 2323.

Probably most nearly allied to *C. flexuosus* Wats., from which it is readily distinguished.

Mirabilis limosa, n. n.—*M. glutinosa* A. Nels., Proc. Biol. Soc. Wash. **17**:92. 1904; not *M. glutinosa* Kuntze, Rev. Gen. **3**²:265. 1898, the latter a Bolivian plant; *Hesperonia glutinosa* (A. Nels.) Standley, Contrib. U. S. Nat. Herb. **12**:365. 1909.

Lesquerella tenella, n. sp.—A delicately slender erect annual, 2–4^{dm} high, beginning to blossom when very small; uniformly but not densely stellate pubescent throughout: stems one or more from the summit of the slender tap root, unbranched: leaves rather distant, narrowly oblanceolate to linear, 1–4^{cm} long, usually tapering to a slender petiole: petals broadly spatulate, very obtuse or slightly retuse, about 8^{mm} long, twice as long as the lanceolate sepals: pod globose, not stipitate, about 5^{mm} long; the style about 3^{mm} long; the pedicel 10–15^{mm} long and variously curved and spreading or even reflexed.

Moapa, Nevada, April 8, 1905, *Goodding* 2184.

This species belongs in the section having immarginate seeds and with the annual species having globose pods; however, it has no known near relative.

Linum leptopoda, n. sp.—Having the appearance of a perennial but possibly only biennial, wholly glabrous, 3^{dm} or more high: root stout, with white furrowed bark, the caudex-like branched crown bearing several to many slender erect terete stems dividing into filiform branchlets above: leaves crowded below; those of the crowns scale-like, very short, 2–4^{mm} long and half as broad, leaving a crestlike scale when falling away; lower stem-leaves 5–12^{mm} long and 1–3^{mm} wide, becoming narrower, more distant, and finally bractlike above; stipular glands wanting: pedicels slender, 5–25^{mm} long: sepals about 5^{mm} long, green or brownish red, lanceolate, 1-nerved, with a few obscure glands on the margins as have also the bracts: petals a clear yellow, 7–9^{mm} long, broadly obovate or suborbicular, with obscurely crenate summit: stamens as long as the united part of the styles; the anthers large, as long as the filaments: styles united a little more than half their length: capsule about as long as the sepals, the false septum incomplete.

Las Vegas, Nevada, on stony slopes, May 4, 1905, *Goodding* 2276.

Except for the yellow flowers, this suggests at first glance *Linum Lewisii* rather than any of the yellow-flowered species.

Mortonia utahensis, n. sp.—*M. scabrella utahensis* Coville, ex. Wm. Trelease, Syn. Fl. N. A. **1**:400. 1897.

Specimens in full bloom, April 19, no. 2230, in the Muddy Range; fruiting specimens May 13, no. 2369, Las Vegas Mts., both localities in southern Nevada.

The excellent collections of this plant by Mr. GOODDING in 1905 leave no doubt that it ought to be considered distinct from *M. scabrella* Gray. Not only are the leaves uniformly much larger, but the flowers are very numerous and much smaller. The calyx-lobes equal and in fruit rather exceed the turbinate tube; they are broadly triangular, with erose scarious margins. The petals are nearly oval, with erose denticulate margins, and are narrowed abruptly to a short claw-like base; they barely equal the calyx-lobes and are never more than 3^{mm} long. The filaments are dilated downward. The leaves do not have revolute margins but are fleshy-thickened, looking as if bordered with cartilage.

Condalia divaricata, n. sp.—An intricately branched rigid shrub, $2–4^{m}$ high; the branchlets crowded, $3–7^{cm}$ long, strongly divaricate (at right angles to the stem), rigid, permanently covered with a fine close tomentum which at tip shades off to flaky deciduous scales, leaving the sharp brown spine free: leaves in approximate alternate fascicles, mostly on the spinelike branchlets, nearly sessile, somewhat thick and coriaceous, the margin wholly entire, permanently lanate-pubescent, oblong to oval, or sometimes narrowed toward the very short petiole, mostly obtuse at apex, the venation obscure, rarely more than the midrib showing, $4–8^{mm}$ long: flowers not known: mature fruit on very short peduncle and pedicels (each less than 2^{mm} long), the umbel apparently 3-flowered at most: drupe ellipsoidal, purplish black, $5–7^{mm}$ long (in dry specimens), the stone moderately thick-walled, completely 2-celled, with a large elliptical plano-convex seed in each cell.

Las Vegas, Nevada, in mature fruit, May 5, 1905, *Goodding* 2300.

The only species to which this is closely allied is *C. lycioides* Weberbauer, but that is a Texan species with narrower thin pale leaves conspicuously veined, and with subglobose fruit. The var. *canescens* of this species, at least as originally described (GRAY, Wheeler Rept. **6**:82), is a shrub only half as large, with greenish branches covered with a "gray powdery substance," leaves on petioles $4–8^{mm}$ long, and the spiny branchlets only $12–25^{mm}$ long. Though no specimens of the variety are at hand, it seems highly improbable that it is the same as the one now described. Should such prove to be true, it certainly deserves to be separated from *C. lycioides*, as is now done.

Mentzelia polita, n. sp.—Perennial, but probably short-lived:

root semi-woody, with a branched crown: stems 2 to several from the crowns, rather slender, erect, 2–4^{dm} high, somewhat cymosely branched at summit, glabrous, polished ivory white: leaves all entire; the lower narrowly spatulate-oblanceolate, sometimes abruptly acute, all but the lowest sessile; from the middle up linear, and the uppermost broadest at the base; all obscurely papillose, with a minute seta from the center of the papilla, and closely covered with microscopic pointlike hairs barbed at the summit: calyx-tube short-turbinate, about 5^{mm} long: petals white, spatulate, 10^{mm} long: stamens numerous, a few of the outer filaments dilated-petaloid but all fertile, shorter than the petals: style stout, not cleft at apex: capsule globose, crowned by the divaricate and now somewhat subulate calyx-lobes.

Las Vegas, Nevada, from washes in the hillsides, May 4, 1905, *Goodding* 2273.

Mentzelia synandra, n. sp.—Harsh and hispid throughout, duration not known (roots wanting in type collection): stems apparently several from the base, somewhat branched, 3–4^{dm} high, with long whitish aciculae and the short barbed pubescence of this genus: leaves mostly broadly elliptic-ovate, somewhat irregularly dentate, 3–6^{cm} or more long, the petioles usually much shorter; the upper surface bearing long aciculae with pustulate bases, and the lower long barbed hairs, both kinds mingling on the petioles and inflorescence: calyx-tube 10–14^{mm} long, somewhat exceeded by the linear-lanceolate lobes: petals 5, yellow, obovate-spatulate, abruptly acute, 3–4^{cm} long: stamens very numerous, all similar but the inner successively shorter; anthers oblong-oval; the filaments filamentous, not longer than the calyx-lobes, all connate at base, forming a firm thick-walled ring to which the petals cohere by their bases, the whole deciduous together from the firm rim of the calyx-tube: style stout, the 3–5 stigmas more or less convolute: fruit unknown.

Las Vegas Mountains, southern Nevada, May 13, 1905, *Goodding* 2373.

A very remarkable species, simulating the arrangement of petals and stamens in the Malvaceae.

Chylisma hirta, n. sp.—A coarse biennial, 3–5^{dm} high, branching from the lower part of the stem or from the crown, densely white-hirsute on the stems, less coarsely so on the leaves and sparsely on the pods: leaves mostly basal (the crown-leaves wanting in the type),

very variable, 5–10^{cm} long or more, somewhat lyrate; the terminal lobe large, elliptic-ovate, irregularly crenate-dentate or entire; the lateral lobes irregular, small, few to many or even wanting: flowers large, crowded but ultimately evolving an elongated large-fruited raceme: calyx-tube turbinate, 4–5^{mm} long; its lanceolate lobes twice as long, with a short hornlike appendage near the tip: petals yellow, obovate-orbicular, about 15^{mm} long: stamens about equal; filament and anther each about 5^{mm} long: style shorter than the petals: capsules 5–6^{cm} long and 2–3^{mm} broad, on pedicels 5–15^{mm} long: seeds numerous, somewhat ovoid but irregular and angled through pressure, 2–3^{mm} long.

Tuly's Ranch, thirteen miles from Las Vegas, Nevada, in stony washes, May 1, 1905, *Goodding* 2348.

Lavauxia lobata, n. sp.—Biennial or possibly more enduring, the rather thick root with an enlarged more or less branched crown: stemless or more usually caulescent, softly and conspicuously hirsute throughout: leaves crowded on the crowns and short stems, 1–2^{dm} long, narrowly oblanceolate in outline, irregularly and deeply pinnately lobed; the lobes mostly oblong, obtuse or subacute, 5–18^{mm} long: calyx-tube 7–9^{cm} long; its lobes ovate-lanceolate and about 25^{mm} long: corolla yellow, changing to red with age; the petals as long as the calyx-lobes and a third broader than long: style as long as the petals, with long-linear stigmas: capsule linear-lanceolate, sharply angled but not winged, tapering very gradually from the base, 4–6^{cm} long, 4–6^{mm} broad: seeds 2–3^{mm} long, with conspicuous tubercle.

Meadow Valley Wash, Nevada, in sandy washes, April 7, 1905, *Goodding* 37 and 47 (type).

This fine species might readily be mistaken for a yellow-flowered Pachylophus, did it not have the angled capsule and tubercled seeds of Lavauxia.

Pachylophus cylindrocarpus, n. sp.—Biennial, stemless or more often developing a stoutish stem 1–2^{dm} high: leaves narrowly oblong-lanceolate, nearly entire to irregularly and lacerately dentate, almost glabrous on the faces but with a white fringe of soft hair on the margins; blade 5–15^{cm} long, on petioles as long or longer: calyx (including ovary) softly white-hirsute; its lobes linear-lanceolate, nearly 3^{cm} long: petals broadly cuneate-obcordate, with deep sinus, equaling

or exceeding the calyx-lobes: capsule nearly glabrous, narrowly cylindrical-oblong, 4–6^{cm} long, on a pedicel about 1^{cm} long; a double row of small sharp crests on each obtuse angle: seeds light brown, 2–3^{mm} long, obscurely bidentate at apex, the raphal furrow conspicuous.

Carson's, Meadow Valley Wash, southern Nevada, May 26, 1902, *Goodding* 960a.

Quincula lepidota, n. sp.—Very pale as if canescent, but without pubescence except minute white pustular scales which are very numerous on calyx, pedicels, and petioles, and occur sparingly on the veins: perennial from rather thick rootstocks, the stoutish stems arising at intervals either singly or in clusters: stems erect, short (probably not much exceeding 1^{dm} in length even at maturity): leaf blades fleshy, mostly oval, from entire to undulate crenate, 12–25^{mm} long, the narrowly margined petiole usually longer: pedicels slender, 10–25^{mm} long: calyx-lobes triangular, shorter than the 2–3^{mm} long tube: corolla 12–14^{mm} long and broad, campanulate-funnelform, purple, with an orange-yellow band running from the middle of each lobe toward the base of the tube, where there is a crown of 5 woolly crests, the 5 slender filaments alternating with the crests: style longer than the filaments but shorter than the corolla; ovary glabrous: fruiting calyx and berry not known.

Dry Lake, Nevada, in the gumbo soil of a dry lake bed, April 17, 1905, *Goodding* 2232.

The appearance of this species is so different from that of *Q. lobata*, the only other species of the genus, that were it not for the character of the pubescence and the crown in the base of the corolla one would refer it, in the absence of fruit, to Chamaesaracha rather than to Quincula.

Physalis genucaulis, n. sp.—Perennial from a stout woody tap root, 1^{dm} or more long; densely but minutely pruinose or viscid puberulent throughout, and with no long hairs: stems several, each more or less branched; the branches with short zigzag internodes, 2–3^{dm} high: leaves ovate to ovate-triangular, the base varying from abruptly cuneate to cordate, 1–3^{cm} long: calyx campanulate, about 5^{mm} long, the triangular lobes about half as long as the tube: corolla greenish yellow, without conspicuous spots, campanulate-funnelform, about 10^{mm} long: style shorter than the corolla and just surpassing

the oblong anthers: fruiting calyx equally but not conspicuously 10-angled, noticeably reticulate-veined, ovoid, with sunken base and connivent lobes closing the orifice.

Mesquite Well, southern Nevada, May 1, 1905, *Goodding* 2247.

One might think of referring this to *P. crassifolia* Benth. were it not for character of the fruiting calyx, or to *P. muriculata* Greene, if dealing with the vegetative characters alone.

AMPHIACHYRIS FREMONTII **spinosa,** n. var.—Intricately and divaricately branched, many of the branches naked and slenderly spinose, floriferous twigs not surpassing the foliar ones; scabro-puberulent on foliage and young twigs: leaves oblong to elliptic, acute at both ends, 5–12^{mm} long: heads congested-glomerate: ray sharply 3-toothed.

Moapa, Nevada, April 8, 1905, *Goodding* 2199.

HYMENOCLEA FASCICULATA A. Nels., BOT. GAZETTE **37**:270. 1904.

MR. GOODDING again secured this species, this time at Cane Springs, Meadow Valley Wash, Nevada. These specimens are in perfect accord with the type collection, no. 662, Kernan, Nevada.

HYMENOCLEA FASCICULATA **patula,** n. var.—Slender stems (7–10^{dm} long) widely procumbent or drooping; branchlets assurgent from the stems upon which they are uniformly placed, and not fasciculately clustered at the ends; the very short floriferous twigs similarly distributed upon the branches, and the little glomerules of 3–5 heads (staminate and pistillate) open racemosely or almost spicately arranged upon the branches: involucral bracts of the staminate heads nearly entire; those of the pistillate heads very broadly reniform.

Moapa, Nevada, April 8, 1905, *Goodding* 2178.

BAILEYA PLENIRADIATA **perennis,** n. var.—Stems numerous, crowded in a dense cluster on the crown of a large indurated root, 3–5^{dm} high, leafy almost to the summit.

Moapa, Nevada, April 8, 1905, *Goodding* 2176.

Typical *B. pleniradiata* is an annual. This perennial form is more robust, and has a larger number of bracts (about 40) in the involucre and more disk-flowers (60–75). As pointed out by HALL (Comp. S. Calif. 164), the original *B. multiradiata* Harv. & Gray (Emory Report 144) is not the *B. multiradiata* Gray of Syn. Fl. **1**:318, but is the var. *nudicaulis* of that work.

Gaillardia pedunculata, n. sp.—Winter annual or biennial, 2–4^{dm} high: stems few to several from the crown of the slender tap root, leafy on the lower one-fourth only, the rest being the slender monocephalous peduncle, softly cinerous-hirsute: leaves irregularly pinnatified to entire, oblanceolate to linear, 2–6^{cm} long, more or less petioled, slightly viscidly pubescent especially when young: involucral bracts in about 2 rows, moderately whitened with flat woolly hairs, shorter than the disk which is 12–14^{mm} wide and high: rays 2^{cm} or less long, clear yellow, minutely pubescent on the outside, cleft one-third their length into lanceolate lobes, tapering cuneately from summit to the short very slender tube: disk-flowers also yellow; limb tubular, densely and minutely pubescent with beaded hairs: pappus of very thin paleae about as long as the inordinately pubescent achene, much shorter than the disk corollas, narrowly to broadly elliptic, mostly obtuse, and without costa or awn: fimbrillae of the receptacle nearly obsolete, consisting of a few short slender teeth.

Moapa, Nevada, April 8, 1905, *Goodding* 2177.
This seems to have no near relative among described species.

Enceliopsis, nov. gen.—*Enceliopsis* Gray, Proc. Am. Acad. **19**:9. 1883, and Syn. Fl. **1**: 283. 1894, as Section I of Helianthella.—Xerophytic plants, perennial from an indurated branching caudex, the crowns of which bear the rather thick simple leaves and the single long pedunculate monocephalous scape. Leaves canescent, and the petioles usually margined and longer than the blade. Heads large; the involucral bracts in 2 or 3 series. Bracts of the receptacle chaffy, hyaline, or scarious with greenish tip, and more or less conduplicate. Rays (rarely wanting) yellow, conspicuous, pubescent on the exterior, 20–40. Disk-flowers also yellow, with short narrow tube, abruptly expanded into the longer cylindrical throat. Achenes flat, oblong-cuneate, with narrow callous margins and the broadly retuse summit with a wider crownlike callus, from densely to thinly villous. Pappus of two subulate awns and in some species a narrow fringe of confluent squamellae between them; rarely even the awns wanting.—Plants peculiar to the "limestone clays" of the desert Southwest (southern Utah and Nevada, and adjacent Colorado, New Mexico, and Arizona).

The species for which this new genus is proposed were most of them described under Encelia, but have in more recent years been transferred to Helianthella, and sometimes back again. This of course indicates that they do not conform to either genus, and since the five species constitute a very homogenous and characteristic group it seems far better to give them generic rank. *E. nudicaulis*, though not the oldest of the species, was the first to be correctly and completely delineated, and may be cited, therefore, as the type of the genus. Mr. MARCUS E. JONES has well called attention to the fact that these are singularly out of place in Helianthella so far as habitat is concerned. The true species of that genus belong in the mountains, mostly in cold moist situations in high altitudes; while Enceliopsis occurs only in absolutely the hottest, driest area to be found on this continent.

Enceliopsis nudicaulis, n. comb.—*Encelia* (§ GERAEA) *nudicaulis* Gray, Proc. Am. Acad. **8**:656. 1873; *Helianthella nudicaulis* Gray, Proc. Am. Acad. **19**:9. 1883; *Encelia nudicaulis* Jones, Proc. Calif. Acad. Sci. II. **5**:701. 1895.

Enceliopsis argophylla, n. comb.—*Tithonia argophylla* Wats., Bot. King's Rep. **5**:423. 1871; *E. argophylla* and *H. argophylla* Gray, in turn, as above; not *H. argophylla* Coville, Contrib. U. S. Nat. Herb. **4**:132. 1893; *E. argophylla* Jones, *l. c.* 702.

Enceliopsis grandiflora, n. comb.—*H. argophylla* Coville, Contrib. U. S. Nat. Herb. **4**:132. 1893; *E. grandiflora* Jones, *l. c.* 702; *H. Covillei* A. Nels., BOT. GAZETTE **37**:273. 1904.

Enceliopsis nutans, n. comb.—*E. nutans* Eastwood, Zoe **2**:230. 1891; *Verbesina scaposa* Jones, Zoe **2**:248. 1901.

Enceliopsis tuta, n. sp.—The large woody root crowned with a widely and freely branching caudex; the branches thick, 2–10^{cm} long, protected from desiccation by a thick felted sheath of white wool: leaves all on the crowns, densely and minutely appressed-cinerous or silvery white, rather small, 15–25^{mm} long, narrowly to broadly elliptic-ovate, mostly cuneately subacute at both ends; the barely margined petiole usually much longer than the blade: scape rather slender, 15–30^{cm} long: involucre hemispherical, 20–25^{mm} broad, its pubescence similar to that of the leaves but longer; involucral bracts in about 2 series, narrowly lanceolate, the outer 9–11^{mm} long, the inner a little longer: rays puberulent, as in the other species, 20–25^{mm} long, linear, entire or 2–3-toothed at the slightly broadened apex: chaffy bracts of the receptacle equaling the disk-flowers: achenes softly hoary-villous, the dark body (when wet) in fine contrast

to the white margin and crown, about 1^{cm} long, the slender incurved awns fully one-third as long and wholly free from and surpassing the hair on the achene: glandular waxlike particles occur abundantly on the flowers and free tip of the chaff.

Las Vegas, Nevada, May 4, 1905, *Goodding* 2271.

Chaenactis paleolifera, n. sp.—Biennial or possibly perennial: the tap root with an enlarged indurated crown bearing few to several freely branched stems, $1.5–3^{dm}$ high: leaves numerous, pinnately parted into few to several mostly short linear entire segments, canescently tomentulose as are also the stems and involucres: heads numerous, terminating the branchlets, naked pedunculate, $12–15^{mm}$ high and broad, 40–60-flowered: involucral bracts linear-lanceolate, slightly acuminate: receptacle convex, with numerous (as many as the flowers?) paleae; these linear, clavellate-acuminate above, and minutely glandular-pubescent, as are also the corollas, which exceed the paleae but little: corollas ochroleucous, essentially alike; their tubes a little shorter than the slightly enlarged throat: stamens included: stigmas exserted: pappus paleae 4, usually lance-acuminate and as long as the corolla-tube, sometimes shorter and obtuse, or slightly lacerate: achenes linear, slightly enlarged upward, and nearly terete, softly pubescent.

Tuly's ranch, 13 miles north of Las Vegas, Nevada, May 10, 1905, *Goodding* 2344.

Only two other species are accredited with paleae, *C. carpoclinia* and *C. attenuata* Gray, with 10 and 5 paleae respectively. These, apart from the differences in the number of paleae, cannot be confused with the species here proposed.

LEBETINA Cass. in Dict. Sc. Nat. **25**:394. 1822.—Among the several names to which the following species have been referred, Lebetina seems to be the earliest and the only one proposed especially for any of them. Dysodia, as at present constituted, includes most diverse things, and in the section EUDYSODIA extreme incongruity seems to have been reached (see GRAY, Proc. Am. Acad. **19**:37. 1883; HOFFMANN, ENGLER & PRANTL, Pflanzenfam. 4^5:266. 1890). HOFFMANN assigns the first of the following to a section by itself, but had he added the other species the section would still have been fairly homogeneous and would have relieved the section EUDYSODIA. To think of *Dysodia papposa* and *D. Cooperi* Gray as congeneric stretches one's

scientific imagination too far; therefore, I suggest the recognition of the genus Lebetina, with at least the species named below. These species in habit and habitat and in most essentials of structure are in close accord, the first being exceptional in having an extra series of paleae, and the first and second in that the style appendages are abruptly instead of gradually acuminate. The characters of the genus can be obtained from the description of the section EUDYSODIA and its subdivisions, as cited above, and in Syn. Fl. **1**:356. 1884.

Rather than leave these species in Dysodia, it were better to transfer them to *Porophyllum* Vaill, or to *Nicolletia* Gray, in either of which less violence would be done so far as appearance gives any clue to general conformity.

LEBETINA CANCELLATA Cass.—*Dysodia cancellata* Gray, *l. c.;* and Hoffmann, *l. c.*

Lebetina porophylla, n. comb.—*D. porophylla* Cav., Anal. Cienc. **4**:334; D.C. Prodr. **5**:639; not *D. porophylla* Willd., Enum. 900.

Lebetina speciosa, n. comb.—*D. speciosa* Gray, Proc. Am. Acad. **5**:163. 1861.

Lebetina porophylloides, n. comb.—*D. porophylloides* Gray, Mem. Am. Acad. **5**:322. 1855; and Bot. Cal. **1**:397. 1886.

Lebetina Cooperi, n. comb.—*D. Cooperi* Gray, Proc. Am. Acad. **9**:201. 1874; and Bot. Cal. **1**:397. 1885.

The collection of this last species by Mr. GOODDING (no. 2246, Mesquite Well, Nevada) led to a study of this group, which has convinced me that Dysodia will receive further segregation, though it may at the same time be expanded in certain other directions. HOFFMANN has thus referred *Thymophylla* Lag. (*Hymenatherum* Cass.), and has found it necessary to change the generic description in no essential character. For that reason the following may be referred to Dysodia.

Dysodia cupulata, n. sp.—Herbaceous perennial, from slender woody roots; puberulent on stems and leaves; foliage and involucre more or less beset with small round oil-glands; branching below: stems slender, less than 1^{dm} high, very leafy; branchlets terminating in a filiform naked monocephalous peduncle $2–4^{cm}$ long: leaves opposite below, pinnately parted into 3–5 filiform acerose lobes $1–2^{cm}$ long: involucres broadly campanulate or cup-shaped, about 5^{mm} high and broad; bracts about 16, completely united, 1 or 2 minute free bracts at base: rays about 12; ligule elliptic-oblong,

2–3^{mm} long, fertile, yellow: disk-flowers also yellow, numerous, slightly exceeding the pappus, one sinus more deeply cleft than the others: pappus of 10 narrow paleae, united at base and in a single series, obscurely bidentate at apex, the mid-nerve continued from between the teeth as a minutely scabrous seta as long as the palea, the alternate paleae and setae shorter: achene linear subterete, obscurely ciliate-pubescent, 2–3^{mm} long, as long as the longer setae: stigmas obtuse.

Tuly's Ranch, Las Vegas, Nevada, May 10, 1905, *Goodding* 2343.

This is probably very near to *Hymenatherum Thurberi* Gray (Proc. Am. Acad. **19**:41 and Syn. Fl. 1:358) and it may have to become *Dysodia Thurberi*. The description of that species is such as to make it difficult to settle the question positively in the absence of the type or of authentic material, but the geographical distribution makes their identity quite improbable.

Dysodia fusca, n. sp.—Pubescence minute, scurfy-glandular: plants low, 1–2^{dm} high, freely branched from a woody base; the ultimate branchlets very slender, fragile, white: leaves numerous, opposite, crowded (the internodes short), very narrowly linear, all or nearly all entire, mucronate, with few to several dark oval oil-glands: heads nearly sessile, campanulate-turbinate, 5–8^{mm} high: involucre cupulate, only the very short obtuse tips of the bracts free, with a few subulate accessory bracts at the base and with few to several oil glands: ligules oblong, 5–8, about 4^{mm} long: disk-flowers about as many, very narrow: anthers and stigmas included, the latter truncate, with an obscure apiculation: pappus paleae of both kinds of flowers wholly resolved into unequal scabrous capillary bristles as long as the disk corollas, fuscous and protruding brushlike from the involucre of mature heads: achenes linear, very finely striate, minutely pubescent, subterete, as long as the pappus: receptacle alveolate, naked, or with a few soft scattering hairs.

Muddy Range, southern Nevada, in a stony wash (three plants), April 10, 1905, *Goodding* 2214.

This seems to fall into GRAY's section BOEBERA (Syn. Fl. 1:356) and possibly may be allied to the two Mexican perennials mentioned. Those, however, have pedunculate heads and the leaves pinnately divided as is usual in the genus. Only the most liberal interpretation of the genus admits this species, and were it not for the gamophyllous involucre it were better to place it in Pectis, which it resembles in habit and in the opposite somewhat connate leaves.

PLANTAE MISCELLANEAE

Euphorbia manca, n. sp.—Annual, the decumbent base giving rise to few to several simple, erect branches 1–2^{dm} high: leaves obovate-cuneate, broadly obtuse, numerous, the lower reduced: primary floral bracts ovate-reniform; the secondary broadly reniform, sometimes connate: inflorescence once or twice trichotomous: capsule about 4^{mm} long: seeds short cylindrical-oblong, gray but not ashy, nearly smooth.

Mancos, Colorado, June 23, 1898, *Baker, Earle, and Tracy* 23.

This has been referred to *E. crenulata* Engelm. by NORTON in Rep. Mo. Bot. Gard. **10**:36. 1899. That species, as there constituted, however, is clearly an aggregate, both annuals and perennials being included even when of very diverse habits. The segregates readily discriminated seem to be as follows:

Perennial with branched stems from horizontal or ascending rootstocks; leaves crenulate; seeds with deep dark-colored pits. 1. *E. Nortoniana*

Annuals:

Stems branched above; leaves crenulate; seeds ash-colored with irregular vermiculate ridges and broad shallow pits. 2. *E. crenulata*

Stem branched from the decumbent base; leaves entire; seeds greenish gray, nearly smooth. 3. *E. manca*

E. crenulata is characterized adequately in the original description in Bot. Mex. Bound. 192; as well as in Wats. Fl. Cal. **2**:75 (as *E. leptocera*, an undoubted synonym); and in Greene, Man. Bay Region 80.

Euphorbia Nortoniana, n. sp.—*E. crenulata* of Norton in Rept. Mo. Bot. Gard. **10**:36. 1899, as to the perennial plant, from which the description is chiefly drawn.

Apparently common in California, the type selected being *Heller* 6625 (San Francisco, April 25, 1903) and 6486 (Pacific Grove, March 30, 1903).

In his key to the species of Euphorbia, NORTON provides for both the annual and the perennial plants (*l. c.* 8); and a very different plant from the above served for the figure on his *pl. 36*.

Gaurella canescens (Torr. and Frem.), n. comb.—*Oenothera canescens* Torr. and Frem., Fremont's Rep. 315. 1845; *Gaurella guttulata* (Geyer) Small, Bull. Torr. Bot. Club **23**:183. 1896.

UNIVERSITY OF WYOMING
LARAMIE, WYOMING

THE LEAVES OF PODOPHYLLUM

J. ARTHUR HARRIS

An inspection of the leaves of the flowering stem of *Podophyllum peltatum* shows that they are not exactly the same size. Furthermore, the larger one seems generally to be inserted a little lower on the axis than the other of the pair. HOLM (**3**) found that the two leaves do not develop simultaneously but that one appears before the other. Concerning this point he writes:

> Of its two leaves, the one is developed earlier than the other. The base of the petiole of this leaf is dilated into a pair of broad wing-like stipules which envelop each other and enclose a small green leaf and a flower bud; thus the two green leaves did not develop at the same time, as it might seem when we examine the plant during its flowering period with its leaves apparently opposite.

Some of the teratological literature has an interesting bearing upon this question of the differentiation of the leaves. PORTER (**8**) illustrates one type in which the flowering stem bears two leaves, the peduncle apparently originating from one of the petioles two or more inches above their insertion. In another form there are three peltate leaves with the peduncle originating between the upper two, which are represented as about equal in size and opposite,[1] or some distance above the fork from one of the petioles. One of the leaves may be much reduced in size, or but one leaf—then apparently terminal and with the peduncle lateral—may appear. Finally both leaves may be absent. FOERSTE (**2**), apparently unacquainted with PORTER'S paper, redescribes these forms and adds other types, similar in a general way. The production of a small, not peltate lamina upon the peduncle is not very rare. The instance observed by BAILEY (**1**) of a flower replaced by a small erect leaf, and mentioned by PENZIG (**7**) as *sehr wunderlich*, was probably merely due to the early abortion of the flower bud in such a case.

The essential point to be gained from the foregoing observations is that the flowering stem of Podophyllum, instead of producing only two opposite leaves, may become an elongated shoot of at least three

[1] Here probably belongs the case described by TRIMBLE (**9**) which PENZIG (**7**) records as not clearly expressed.

leaves. In fact BRITTON and BROWN in the *Illustrated flora* describe the species as "bearing 1–3 similar leaves or sometimes leaflets." The third leaf is frequently small and not peltate, but it may be very similar to the others.

Knowing that more than two leaves are occasionally produced by the flowering stem, and that there appears to be a slight difference in the size and position of the two leaves in normal specimens, two questions occurred to me: (*a*) To what extent are the two leaves of Podophyllum really differentiated in type and variability? (*b*) What is the degree of similarity of leaves from the same individual?

A satisfactory measure of the area of a leaf so irregular as that of Podophyllum is obviously out of the question. It was necessary therefore to select some character other than size. The degree of lobing seems to be the only practicable one, although this character is not so definite as might be desired, and the determination is subject to considerable error due to personal judgment.

The margins of the very excentrically peltate leaves are irregularly toothed, lobed, or divided. It is quite impossible to draw a sharp line of distinction between the smaller lobes and the major divisions of the leaf, but I think that personal judgment would rarely vary greatly in the grading of an individual collection of plants. Perhaps less confidence is to be placed in a comparison of two or more lots taken at different times. In sorting the leaves into classes I counted as lobes the divisions extending at least half-way from the periphery of the leaf to the point of insertion on the petiole; divisions less sharply marked than this were not counted. Only normal plants—that is, those having only two leaves—were included in the collections. In sorting material to determine whether there is a differentiation between the upper and lower leaves of a pair, it is important that the appearance of the leaf lamina does not influence the judgment in any way. In dividing the nearly opposite leaves into upper and lower, the insertion of the petiole alone was examined. After the relative position of the two leaves was thus decided the counts were made.

The first lot of material examined was taken at Valley Park, near St. Louis, Mo., in May, 1906, when the plants were with partly grown fruit. In very few cases was there any question concerning the position to be assigned to the two leaves. All of the countings were made

by myself on one afternoon, so that I think there can be but little error due to variation of judgment. All plants were taken at random, and none were discarded except because of mutilation which rendered the countings untrustworthy, save three which had an extra lamina at the base of the peduncle. The data for the 400 flowering stalks counted appears in the form of a correlation table as table I.

TABLE I

UPPER LEAF

LOWER LEAF	4	5	6	7	8	Totals
5	1	4	3	..	..	8
6	4	34	66	1	..	105
7	1	52	144	28	..	225
8	..	2	22	16	..	40
9	..	..	6	10	1	17
10	..	1	1	2	1	5
Totals...	6	93	242	57	2	400

The second series I secured in the woods at Palos, Athens Co., Ohio, in early July, 1908. It was really too late in the season to work to advantage, for many of the plants were so badly dried that they had to be discarded. I see no reason for believing that this discarding of individuals too brittle to be counted introduces any element of error into the work, though it did considerably increase the labor. The countings were made in as nearly the same manner as for the first series as possible. The data are given in table II.

TABLE II

UPPER LEAF

LOWER LEAF	2	3	4	5	6	7	8	Totals
4	1	..	1	..	..	..	..	2
5	..	..	13	24	..	..	..	37
6	..	2	12	80	4	1	1	100
7	1	..	9	121	42	8	..	181
8	..	..	..	2	8	8	..	18
9	..	..	..	..	1	..	..	1
Totals..	2	2	35	227	55	17	1	339

The physical constants for these two lots are laid side by side in table III. To permit of easy comparison the differences between the constants for the two series, and the probable errors of the differences, are given. Comparing the means for both upper and lower

leaves for the two habitats, we notice that they differ by ten to twenty times the probable errors of their differences. The standard deviations differ by only one and a half to three times the probable errors of their differences. Perhaps the differences between the means of the collections from the two habitats are significant statistically, but I attach no biological importance to the differences, since they may be due merely to some slight local environmental condition. The variabilities certainly do not differ significantly.

TABLE III

VARIATION CONSTANTS FOR LOBING OF PODOPHYLLUM LEAVES

Series of material	Average and probable error	Standard deviation and probable error	Coefficient of variation
VALLEY PARK, MO.:			
Lower leaf	6.920± .029	.848± .022	12.25
Upper leaf	5.890± .022	.666± .016	11.30
Difference	+1.030± .036	+.182± .027	+ 0.95
PALOS, OHIO:			
Lower leaf	6.528± .029	.792± .021	12.13
Upper leaf	5.139± .027	.742± .029	14.43
Difference	+1.389± .040	+.050± .036	− 2.31
DIFFERENCES:			
Lower leaf	+0.392± .041	+.056± .030	+ 0.12
Upper leaf	+0.751± .035	−.076+.025	− 3.13

Taking now the question (*a*), that of a differentiation between the upper and lower leaves, we note that the means differ in both cases by about thirty times the probable error of their differences, and that the lower leaf has in both cases about one lobe more than the upper. The standard deviations differ by an amount which can hardly be regarded as significant. The relative variability as measured by the coefficient of variation is in one case higher for the upper leaf and in one case lower. After calculating the constants for the first series of material, I thought that perhaps the variability of the more distally placed leaf would be regularly lower than that of the more proximal one, as PEARL (**4**) found the variability of the whorls in Ceratophyllum to be. But the second series does not support this idea.

It may be interesting to compare the variability in the lobing of the leaves of Podophyllum with that of other leaf characters given by PEARSON (**5**). From page 361 I note the following values of the coefficient of variation for leaf characters:

Holly, Dorsetshire, prickles on leaves	26.29
Holly, Somersetshire, prickles on leaves	18.74
Ash, Dorsetshire, leaflets on leaves	18.65
Ash, Monmouthshire, leaflets on leaves	18.57
Ceterach, Somersetshire, lobes on fronds	18.25
Wild ivy, mixed, leaf-indices	17.77
Spanish chestnut, mixed, veins in leaves	15.72
Ash, Buckinghamshire, leaflets on leaves	15.46
Spanish chestnut, Buckinghamshire, veins in leaves	14.31
Beech, Buckinghamshire, veins in leaves	10.77

It appears by these comparisons that the lobing of the leaves of Podophyllum is rather less variable than leaf characters in general.

Turning now to the question of the degree of similarity between the two leaves, and calculating the coefficient of correlation between the number of lobes on the lower leaf and the number of lobes on the upper leaf by the familiar product-moment method, we find the correlations,

For the Valley Park series	.428± .028
For the Palos series	.468± .029
Difference	.040± .040

I was considerably surprised when these values turned up on my dividing machine. A priori, I would have expected considerably higher coefficients, say about .700, for the correlation between organs so closely associated as the leaves of Podophyllum. In thinking of the correlation between the leaves of Podophyllum, it had always seemed to me organic rather than homotypic in nature. The two leaves seemed so nearly exactly opposite and the whole "normality" of the plant seemed to depend so much upon their forming a symmetrical pair that I had expected the usual homotypic resemblance plus something more.[2] But instead we find values which fall directly in line with those found by PEARSON and others for homotypes in general. Taking merely the leaf characters noted above, we find the homotypic relationship calculated by PEARSON and his coworkers (**5**) to be the following:

Ceterach, Somersetshire, lobes on fronds	.631
Holly, Dorsetshire, prickles on leaves	.599

[2] For a clear statement of the distinction between organic and homotypic correlation see page 340 of PEARSON's splendid reply (**6**) to BATESON's criticism of the theory of homotyposis.

Spanish chestnut, mixed, veins in leaves	·591
Beech, Buckinghamshire, veins in leaves	·570
Spanish chestnut, Buckinghamshire, veins in leaves	·466
Ash, Monmouthshire, leaflets on leaves	·405
Ash, Dorsetshire, leaflets on leaves	·396
Ash, Buckinghamshire, leaflets on leaves	·374
Holly, Somersetshire, prickles on leaves	·355
Wild ivy, mixed, leaf-indices	·273

Some of these are slightly higher and some slightly lower than our coefficients; but when the probable errors attached to all constants are borne in mind, I think we cannot assert that our values are very different from those obtained by English biometricians for other leaf characters. Furthermore PEARSON shows reasons for considering some of his values too high and some too low for true homotypic relationships. For instance, ceterach is said by botanists to be largely influenced by growth and environment.[3]

There still remains one possible reason for thinking that the real correlation between the number of lobes on the leaves of the same flowering stalk may be somewhat higher than is indicated by these constants. The May apple spreads considerably by rootstocks. My plants from both habitats were taken from quite a wide stretch of woods, but a considerable number of the plants are doubtless vegetatively related. I do not believe this has a very large influence in my series, but it is proper to mention the point.

[3] From the arithmetical side there are also difficulties. I did not apply SHEPPARD'S correction for the second moment in calculating my standard deviations. Perhaps this should have been done, but until some mathematician works out the theory, biologists will not know what rule to follow in the case of integral variates. In the case of a range of variability so narrow as we have here, SHEPPARD'S correction would make a considerable difference, raising the coefficient of correlation by lowering the standard deviations. So perhaps our values should be a little higher.

There is also the question of leaves which fall on the borderline between n and $n+1$ lobes. In the present study I carefully tried to throw these into the class to which they most nearly belonged, just as one would have to do in the case of real integral variates. But after all, the lobing of the leaf of Podophyllum is not a case of discrete variation, and if I were repeating the work I would divide questionable cases between adjoining grades. Probably this would not make a very great difference in the end result.

The reader will note, too, that I am discussing "homotypic" correlation on series of material which I have just demonstrated to be differentiated. But I think I am quite justified in treating the material as I have done, for lower and upper leaves have always been kept separate. There has been no mixing of heterogeneous material.

Summarizing, we may say that so far as our materials show: (*a*) there is a sensible differentiation between the two leaves of the flowering stalk of Podophyllum in the number of lobes, but apparently not in the variability of the lobes, at least not in their relative variability; and (*b*) the correlation between the number of lobes on the two leaves of the stalk lies somewhere in the neighborhood of .45, agreeing well with the homotypic correlations for leaf characters in other species.

CARNEGIE INSTITUTION OF WASHINGTON

LITERATURE CITED

1. BAILEY, W. W., Bull. Torr. Bot. Club **13**:111. 1886.
2. FOERSTE, AUG., The May apple. Bull. Torr. Bot. Club **11**:62–64. 1884.
3. HOLM, T., *Podophyllum peltatum:* a morphological study. BOT. GAZETTE **27**:419–433. 1899.
4. PEARL, R., Variation and differentiation in Ceratophyllum. Pub. 58 Carnegie Inst. Wash. 1907.
5. PEARSON, K., and others. Mathematical contributions to the theory of evolution. IX. On the principle of homotyposis and its relation to heredity, to the variability of the individual, and to that of the race. Phil. Trans. Roy. Soc. Lond. A. **197**:285–379. 1901.
6. ———, On the fundamental conceptions of biology. Biometrika **1**:320–344. 1901.
7. PENZIG, O., Pflanzenteratologie. Genoa. 1890–94.
8. PORTER, T. C., Variation in *Podophyllum peltatum*. BOT. GAZETTE **2**:117, 118. 1877.
9. TRIMBLE, W., Teratological notes. Bull. Torr. Bot. Club **9**:10. 1882.

A BOTANICAL SURVEY OF THE HURON RIVER VALLEY[1]

VII. POSITION OF THE GREATEST PEAT DEPOSIT IN LOCAL BOGS

GEORGE PLUMER BURNS

(WITH FIVE FIGURES)

The general appearance of the vegetation of the peat bogs in the Huron River valley has been fully described by TRANSEAU (**8**) and it is not necessary to give a detailed account in this paper. The plants are usually growing in a more or less regular zonal arrangement somewhat as follows: (1) open water with submerged plants, (2) water lilies, (3) floating sedge, (4) bog shrubs, (5) tamaracks, (6) maple-poplar, (7) willow or marginal zone.

There is wide variation in the position of the greatest amount of peat deposit and the width of the various zones. Even a casual survey of a number of local bogs emphasizes the fact that the open water is seldom in the center of the original post-glacial lake. The zonal arrangement is usually broken on one side, some zones being entirely lacking. In fact it is not uncommon to have all peat deposit lacking at certain places along the shore. According to some writers (**7**) the greatest accumulation of peat is found on the western side, in regions with prevailing westerly winds. In large basins which are only partly filled it is common to find open water occurring toward the eastern side. The wave-action produced by the westerly wind is supposed to hinder bog plants from obtaining a foothold on the eastern shore. The shoreward push of the ice is also a factor of importance in this connection (**8**, p. 418).

A study of the bogs near Ann Arbor soon revealed the fact that the greatest accumulation of peat on the western side was by no means common to all bogs. In fact the greatest variation was found within very short distances. At Dead Lake it is on the southern side (**1**); at Mud Lake, about one-half mile (800^{m}) west, it is on the northern side (**6**); at First Sister Lake, it is on the western side (**9**); at a small bog near Carpenter's Corner it is toward the east (**7**).

[1] Contribution 112 from the Botanical Laboratory of the University of Michigan.

It seems, therefore, that some other factor must be sought. Plane-table maps were made of a number of bogs and the distribution of plants was carefully plotted. Contour maps of the bottoms of the original post-glacial lakes were then made. In making these maps a drill was made of gas pipe, cut in four-foot (1.2^m) lengths. To the end section was welded a carpenter's auger. With this drill, soundings were made through the peat to the clay bottom of the original post-glacial lake. A base line was run taking the longest diameter of the bog. Along this and at right angles to it, cross lines were drawn every hundred feet (30.48^m) in large lakes and every fifty feet (15.24^m) in small lakes. Borings were made at the intersections of these lines and every hundred or fifty feet on the cross lines. Near the shores it was necessary to make the borings closer, often every five feet (1.5^m). In bogs with open water it was necessary to make all borings through the ice, because it was impossible to hold a boat steady enough to bore through the peat without breaking the drill.

FIRST SISTER LAKE.[2]—This bog is situated a short distance west of Ann Arbor and has already been described by other writers (**8, 9**). It is surrounded on all sides by hills, except for three breaks. To the north was a small post-glacial lake; on the southwest corner it connected, by a narrow channel, with Second Sister Lake. The whole formed a very irregular chain of lakes draining into the Huron River.

The contour map of the bottom of the original post-glacial lake is shown by red lines in *fig. 1*. The heavy line indicates the margin of the original lake as indicated by the peat deposit. The shores rise somewhat abruptly on all sides. The lake had one basin. The deepest part was east of the center, the deepest point being fifty-four feet (16.5^m). From this point the bottom sloped gradually to the eastern shore. On the opposite side the forty-foot (12.17^m) contour made a wide divergence to the west; from this contour the bottom sloped gradually to the shore.

No attempt is made to show the flora of this early time. The black of *fig. 1* shows the arrangement of things as they were last summer. The open water occupies a very small area compared to what it did

[2] Borings were made for the most part by Mr. HAROLD STEELE.

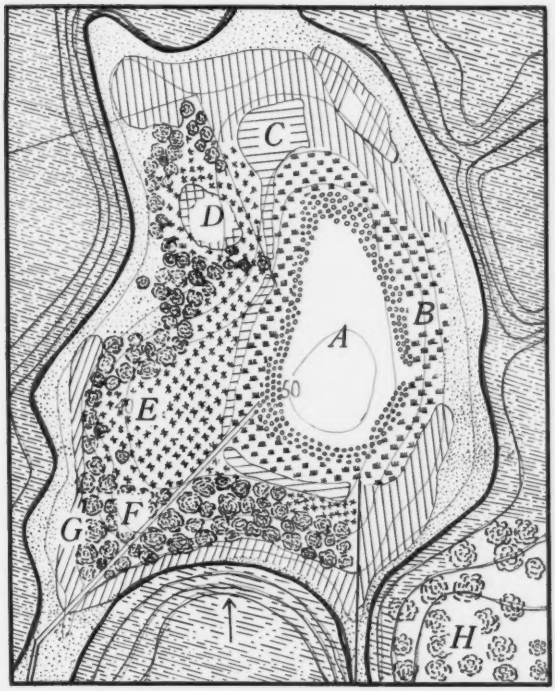


FIG. 1.—First Sister Lake. Contours of the post-glacial lake in red. The heavy line indicates the position of its shore as shown by peat deposit. Scale 1:2880. Contour interval of topography five feet. of hydrography ten feet.

Present distribution of plant societies in black. *A* open water; *B* bog sedge; *C* bog shrub; *D* clearing; *E* tamarack; *F* maple-poplar; *G* willow; *H* oak-hickory.

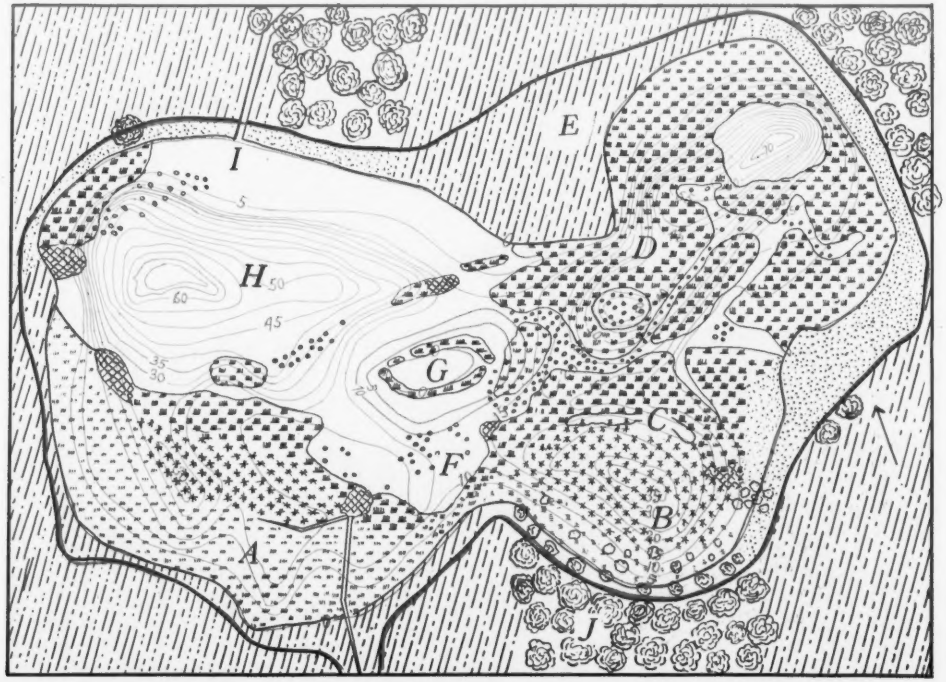


FIG. 3.—Dead Lake. Contours of the bottom of the post-glacial lake in red. The heavy line indicates the position of the shore before drained. The line o indicates the water level when the map was made. Scale 1:4800. Contour interval five feet.

Distribution of plants when the map was drawn in black. *A* area which had been cleared of tamarack before it was suitable for maple-poplar or the clearing society; *B* tamarack; *C* bog shrub; *D* bog sedge; *E* cultivated field; *F* water lilies; *G* island; *H* open water; *I* drain; *J* oak woods.

it was suitable for maple-poplar or the clearing society; *B* tamarack; *C* bog shrub; *D* bog sedge; *E* cultivated field; *F* water lilies; *G* island; *H* open water; *I* drain; *J* oak woods.

originally. The volume of water, however, is much smaller than it appears in the figure just referred to, as is seen in a profile through this section of the lake (*fig. 2*). The greatest accumulation of peat is on the western side. The zonal arrangement is also quite different on the two sides. The bog-shrub, tamarack, and maple-poplar zones are almost entirely lacking on the east. On the west, all the zones are present, the tamarack zone being very wide especially in the southwestern portion.

FIG. 2.—First Sister Lake. Profile east and west. *A* open water; *B* bog sedge; *C* bog shrub; *D* tamarack; *E* maple-poplar; *F* willow. Scale: vertical, 1:600; horizontal, 1:2880.

In *fig. 1* it is interesting to observe that the open water now lies over the deepest part of the post-glacial lake; and to follow the variations in the width of the tamarack zone. The southern area is broken by areas of bog shrubs, showing that the tamarack has not entirely captured the area. The northern group, on the other hand, is disappearing, and when a number of trees were cut out for wood a few years ago an entirely different society of plants came in—a clearing society. In other words, conditions favoring the development of a tamarack society are found where the original post-glacial lake was forty feet (12.17^{m}) or more in depth, and where the depth was less than this conditions are favorable for the development of the next zone of plants.

BOG NEAR CARPENTER'S CORNER.—This is a small bog east of Ann Arbor. It is surrounded by high hills on the north, west, and south. On the east a narrow ridge about five feet (1.5^{m}) high separates it from a large "drained swamp." A ditch has been dug through this ridge to drain the bog. The original post-glacial lake was small,

occupying about one-tenth of an acre (400$^{sq\ m}$). It had only one basin whose greatest depth was fifty-nine feet (18^{m}). This point was considerably west of the center. The slope of the shore from the eastern margin was very gradual for a distance of nearly one-third the east-and-west diameter, when it becomes very steep. The eastern third of the lake was about fifteen feet (4.57^{m}) deep. The slope from the western shore was much steeper, and hence the greatest amount of water was west of the center.

Today the open water has entirely disappeared. From the banks a group of tamaracks may be seen. These are arranged around a small central area within which are found (**7**) a few individuals of the bog-sedge and bog-shrub zones which formerly occupied large areas. Some of the plants found were *Carex filiformis*, *Sphagnum* sp., *Sarracenia purpurea*, *Cypripedium acaule*, and *Vaccinium Oxycoccus*. Outside of this area is a zone of mixed vegetation. The width varies from several rods to a few feet, the widest area being found on the east. The dominant trees are *Acer rubrum* and *Populus tremuloides*. This area has a rather indiscriminate mixture of bog and lowland plants—it is a tension zone in which conditions are not especially favorable to either group of plants. Around this area and following the shore, is found the marginal area so common to bogs. The plants occupying this area are those usually found in low wet places along rivers.

A comparison of this distribution with borings shows that the central area is over the deepest part of the post-glacial lake. The greatest surface accumulation is on the western side where the lake was comparatively shallow, and over this area *Acer rubrum* and *Populus tremuloides* are the dominant trees.

It is thus possible to tell, with considerable accuracy, the depth of the bottom of post-glacial lakes with one basin by the distribution of the present vegetation. The order of succession is lily, bog sedge, bog shrub, tamarack, and maple-poplar. An island of Cassandra located in a zone of *Carex filiformis* indicates a shallow bottom (**3**), but when it is found in a zone of tamaracks it indicates a deep basin.

DEAD LAKE.[3]—This lake is located about ten miles (16^{km}) north

[3] Mr. FOREST B. H. BROWN assisted in making the borings.

of Ann Arbor. Its longest diameter is nearly directly east and west. Red contours on the map (*fig. 4*) show that the bottom of the post-glacial lake was divided into four basins; a rather shallow ridge running north and south divided it into an eastern and western half, and each half is in turn divided into a northern and southern basin. The central ridge was twelve feet (3.65^{m}) deep at the lowest point, and in the center it came above the surface, forming an island.

In the eastern half, the northern basin reached a depth of seventy feet (21.33^{m}) and the southern basin thirty-five (10.66^{m}) feet. However, a large part of this half of the lake was comparatively shallow. Over a large area the depth was about ten feet (3^{m}). The other half was also divided into a deep northern basin which reached the depth of seventy-two feet (21.94^{m}) and a shallower southern basin thirty feet (9.14^{m}). The greater part of this half of the post-glacial lake was deep. At some time in the past a ditch was dug through the bank on the north and the level of the water was lowered several feet. The conflicting stories told by the older inhabitants make it impossible to determine when this occurred. The vegetation, however, shows that it has been a number of years.

The map of the present distribution of plants at this lake (black parts of *fig. 3*) shows that the peat deposit is largely confined to the south and east. The principal vegetation of the lake is the bog sedge. Only on the south have the tamaracks and the bog shrubs gotten a foothold, though "islands" of these are rapidly spreading over the bog sedge in many places. The absence of the bog flora around the shore of the island in the center of the lake (the vegetation shown on the map is *Scirpus lacustris*), along the northern side of the west half, and on the southeastern corner, is no doubt to be explained in part by the action of the wind, wave, and shoreward push of the ice. However, it must be seen from the map that these places do not stand in a definite relation to the points of the compass. Such vacant places are found where there is shallow water. In just such places the actions referred to above would be most intense. It seems, therefore, that the contour of the bottom rather than the direction of the wind is the controlling factor. The small lake in the northeastern corner is over a very deep basin; the deep western half is for the most part open water. The narrow channels of open water on the eastern

portion do not follow the contours but in some places cross them at right angles. Their existence finds its explanation in part in the fact that they are kept open by fishermen who approach the lake chiefly from this side. It is doubtful, however, if this is the entire explanation (**4, 5**). The break in the tamarack zone on the south side is due to two factors. At this point the water was rather shallow and this hindered occupation by bog plants for a long period of years, as has been pointed out; during late years the tamaracks have been cleared away and the place kept open as a watering place for stock. The large open area south of the tamaracks is an area suited for tama-

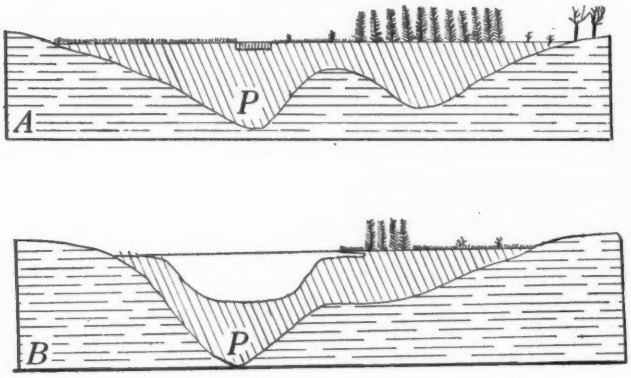


FIG. 4.—Profiles through Dead Lake. *A* through the eastern half; the small body of "open water" is filled with lilies and submerged water plants. *B* conditions in the western part of the lake. Scale: vertical, 1:600; horizontal, 1:4800.

rack growth. The tamaracks formerly growing there were removed for wood and poles before the surface had been raised enough to make it suitable for either the maple-poplar or the clearing society. It is occupied chiefly by marsh ferns and sedges, with a few *Rhus venenata*. A narrow border of *Ulmus americana* is found along the southeastern shore (*fig. 4*).

MUD LAKE.—This lake has been described by PENNINGTON (**6**). It was a very large post-glacial lake but has been almost entirely filled with marl and peat. The greatest deposit of peat is on the northern side, and the open water is very close to the southern shore. In

entering the bog from the north one passes through a number of large areas of bog shrubs, wholly or partly surrounded by tamaracks. In these areas are sometimes found small patches of tamarack and spruce. A profile was run across the bog, north and south, through these areas and the open water. This shows that the areas occupied by tamaracks are located over shallow places in the post-glacial lake, and that areas of bog shrubs are located over deeper basins. The borings showed that this lake had a number of basins very much the same as found at Dead Lake. It has reached a later stage of development, however; the dominant vegetation is the bog shrub and tamarack.

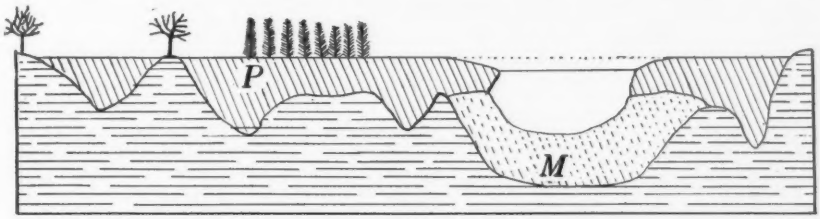


FIG. 5.—Profile north and south through Snow's Lake. The dotted line shows the water level before drained. Scale: vertical 1:300; horizontal, 1:3048.

SNOW'S LAKE.[4]—This lake is located about fifteen miles (24^{km}) west of Ann Arbor. It was formerly a very large lake, but has been almost filled with peat and marl. The bottom of the post-glacial lake was very irregular, as is seen in the profile (*fig. 5*). This profile runs north and south. The deepest and largest basin was near the northern shore; the southern part of the lake was comparatively shallow. A few years ago the lake was drained at the northeastern corner and the level of the water was lowered in the lake. Over the shallow parts of the lake the peat had already become solid, and the draining did not change the level of the surface. Near the open water, however, the plants were still floating, and when the water was drained they sank to the new level. The surface today slants rapidly toward the water; especially is this true for the first few rods immediately next to the open water. It is very surprising from the road to see fine large oak trees growing apparently in the peat bog. How-

[4] A careful study of this lake was made by Dr. JEAN DAWSON, but the results have not been published.

ever, when one goes over to the oak and examines the soil in which it is growing, the matter is easily explained. These "islands" of oak and other upland trees are not growing in peat, but on one of the islands formed by projections from the bottom of the lake. *Fig. 5* shows such an island with an oak growing upon it.

The same relation of present distribution and depth of the original post-glacial lake holds true in lakes with several basins, as it did in lakes with only one: open water over the deepest and largest basins, wide zones of plants where the bottom of the post-glacial lake sloped gradually, a definite order of succession of plant zones. Greater care must be exercised, however, in the determination of depths by the present vegetation, especially in lakes with many small basins just at the time when large areas are beginning to become favorable for the next group of plants. The occupation will take place most rapidly over shallow parts, because here the peat will become firm sooner and the conditions will first be favorable for the next group of plants.

CONCLUSIONS.—The chief factor determining the position of the greatest amount of peat deposit and the width of the zones of plants at the local peat bogs is the depth of the water in the different parts of the original post-glacial lakes. The chief factor in determining the position of the open water is depth; given time enough, the open water will disappear from all our lakes.

In places where the water is very shallow the bog flora is unable to get a start because of the wave-action caused by the winds and on account of the shoreward push of the ice. Such places, however, bear no definite relation to the points of the compass.

Different zones of plants follow in a definite orderly succession; lily, bog sedge, bog shrub, tamarack, maple-poplar.

UNIVERSITY OF MICHIGAN

LITERATURE CITED

1. BURNS, G. P., Formation of peat in Dead Lake. Rept. Mich. Acad. Sci. **6**:76. 1904.
2. ———, Edaphic conditions in local peat bogs. Science N. S. **29**:269. 1909.
3. COWLES, H. C., Physiographic ecology of Chicago and vicinity. BOT. GAZETTE **31**:147. 1901.

4. GANONG, W. F., The vegetation of the Bay of Fundy salt and diked marshes. BOT. GAZETTE **36**:174 and footnote. 1903.
5. ———, On the physical geography of Miscou. Bull. Nat. Hist. Soc. New Brunswick **5**:460.
6. PENNINGTON, L. H., Plant distribution at Mud Lake. Rept. Mich. Acad. Sci. **8**:54. 1906.
7. PETTEE, EDITH E., Plant distribution in a small bog. Rept. Mich. Acad. Sci. **7**:126. 1905.
8. TRANSEAU, E. N., The bogs and bog flora of the Huron River valley. BOT. GAZETTE **40**:429–448. 1905. The older literature is given by this author.
9. WELD, L. H., Botanical survey of the Huron River valley. II. A peat bog and a morainal lake. BOT. GAZETTE **37**:36. 1904.

POLLINATION IN LINARIA

WITH SPECIAL REFERENCE TO CLEISTOGAMY

E. J. HILL

(WITH FOUR FIGURES)

I. POLLINATION BY INSECTS

The genus Linaria furnishes examples of adaptations to both cross- and self-pollination. Of the sixteen species given in KNUTH'S *Handbuch der Blütenbiologie*, nine are said to be visited by insects and may be pollinated by them. One, *L. origanifolia* DC., as observed by MACLEOD, is adapted to insects, but was not seen to use them. Four or five seem to be restricted to self-pollination, and all can also employ it. Some produce cleistogamous flowers, and as far as these can be of service, are compelled to pollinate in this way. *L. vulgaris* Mill. (as *Antirrhinum Linaria* L.) was the first to be observed and described. This was by CH. K. SPRENGEL in his book on the relations of flowers and insects, published in 1793. It was one of the first with which DARWIN experimented when preparing the material for his work on the effects of cross- and self-fertilization in the vegetable kingdom. An unexpected presentation of vigor in one of two beds of this species, planted for the purpose of determining some points regarding inheritance, led him to trials with this and other plants on the results of pollination.

Linaria is called a mellitophilous genus, since bees are the principal agents in the process, though in some species several other insects, especially Lepidoptera, share in the work. The honey, secreted by glands at the base of the ovary, flows into the spur of the flower, where it is stored and awaits the visits of insects with a proboscis long enough to reach it. It is therefore well adapted to visitors of this kind belonging to the class called Eutropic by LOEW.[1] The two pairs of anthers are placed at different heights, with the slender style and the stigma in the space between. These are brushed by the back of a bee crowding in to get the nectar in the spur, or by the longer proboscis of a lepidopter, and some of the pollen is removed

[1] LOEW, Einführung in die Blüthenbiologie 342, 345. 1895.

during the operation. That which was left on the stigma of the flowers by the entering and withdrawing of the bees was the extent of pollination as viewed by SPRENGEL. It was an aid to the plant in securing fertilization indispensable in the case of some, but the full significance in the economy of its life was left for others, especially for DARWIN, to show. SPRENGEL clearly describes the process in the text and figures illustrating *Antirrhinum Linaria*,[2] and in reading his book one wonders at the sagacity of the man so far in advance of his time. The relative position of anthers and stigma, coupled with their simultaneous maturing, can also, as stated by HERMANN MÜLLER, lead just as readily to self-pollination, and in the absence of visits by insects makes it the only possible means of fruitfulness.[3] The same relations hold in the case of the smaller flowers of *L. alpina* Mill., which MÜLLER investigated.[4]

The common toad-flax of Europe, *L. vulgaris*, has been naturalized in this country, and is most frequently seen along roadways or in waste grounds. Two native species are generally recognized, *L. canadensis* (L.) Dumort. and *L. floridana* Chapm. A third, *L. texana* Scheele, is made by some, but by others is considered a large-flowered form of *L. canadensis*. This seems to be the only one that has been studied with regard to its pollination. It is widely distributed, usually growing in dry locations, such as sandy or rocky ground. Its small flowers ally it more to *L. alpina* than to *L. vulgaris*, and like these it is adapted to pollination by insects. CHARLES ROBERTSON observed the flowers in Florida, and found that they were visited by bees, but more often by butterflies. He says of them: "The spur is very slender and the tube has become so contracted that bees can only insert their tongues, and butterflies cannot suck without touching the anthers and stigma. . . . . The palate, which in *L. vulgaris* permits the visits of bumble-bees only, seems to have lost its function, for it is so weak that it entirely fails to exclude butterflies or even flies."[5] Where I have noticed it in the dune region near Chicago,

[2] SPRENGEL, Das entdeckte Geheimniss der Natur im Bau und in der Befruchtung der Blumen 317. *pl. 17. figs. 5–11, 14, 18, 19.* 1793.

[3] MÜLLER, Die Befruchtung der Blumen durch Insekten 279. 1873.

[4] ———, Alpenblumen 275. 1881.

[5] ROBERTSON, Zygomorphy and its causes. III. BOT. GAZETTE **13**:228. 1888.

it does not appear to be very extensively sought by insects, but species of Syrphidae may be seen flitting from flower to flower of this and of plants of *Krigia virginica* in blossom at the same time, perhaps as much in search of pollen as for their sweets.

MÜLLER examined other European species of Linaria with reference to this matter, among them *L. minor* Desf. and *L. arvensis* L. Their flowers are very small, but adapted, like *L. vulgaris* and *L. alpina*, to pollination by bees. As a weed in his garden at Lippstadt he "looked in vain" for visitors to *L. minor*, and *L. arvensis* was repeatedly watched in favorable weather in another station with a like result. Hence he concludes that they are restricted to self-fertilization. As the anthers burst at the same time the stigma matures, should a bee come for the nectar the flowers are ready for cross-pollination. This condition lasts only a short time; the stigma is soon covered with pollen, and self-fertilization is accomplished. Since MÜLLER cannot imagine that a flower, in all the peculiarities of its structure fitted for pollination by insects, should still be very exceptionally visited and crossed by their instrumentality, he concludes that we have in these plants a deteriorating descendant of an ancestor with larger and more striking flowers, in whose pollination bees as a rule took part.[6] He considers that the same is true of various other plants with diminutive or inconspicuous mellitophilous flowers which are now very rarely visited by bees, citing among others *Vicia hirsuta* Koch as a similar case, whose style bears unequivocal marks of arrested development, the brush being reduced to a dozen hairs at most.[7]

II. THE CLEISTOGAMIC CONDITION

It is only a step from this reduction of floral organs mentioned by MÜLLER to flowers so diminutive and constructed in such a way that they do not open at all, or the cleistogamic stage, in which self-pollination is the only means of securing fertility. Of the eight types of entomophilous flowers made by DELPINO, the sixth is that in which the anthers and stigmas are close together and included. Linaria answers these conditions, as must indeed be the case with

[6] MÜLLER, Weitere Beobachtungen III. Verh. nat. Vereins Rheinl. Westf. **39**:28. 1880.

[7] ———, *Ibid.* II. *Op. cit.* **38**:360. 1879.

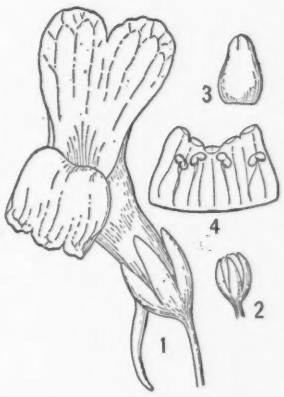
all cleistogamous flowers in respect of the proximity of the organs essential to fertility. It is these cleistogamous flowers I have mainly investigated. My attention was first called to them in 1905, when flowers of this character were found on *L. canadensis* growing upon the sandstone rocks at Oregon, Ill. They were quite inconspicuous. The minute corolla, when pushed off by the enlarging ovary, showed a faint tinge of violet on its upper margin, the main part being colorless. Since it was the middle of July, all traces of the sterile radical shoots had disappeared, as well as such flowers as are ordinarily found earlier in the season, if, indeed, they had been formed at all. The plants were generally small, the shortest mostly with simple stems. Some were branched, the tallest about 4^{dm} high. Since the species is well represented, though not abundant, on the sand dunes at the south end of Lake Michigan, there has been an opportunity to observe it each season since, and to note the different stages of development. The plants begin to blossom about the first of May and continue, in some form, the production of flowers till the middle or latter part of July, when the heat becomes too trying for them in the dry sand. On the larger plants there is a gradual diminution in the size of the flowers from the earliest, $6–8^{mm}$ long, with a diameter of limb of $8–12^{mm}$, till the cleistogamous stage is reached. In some plants of this character, this may occur in the early part of June. It is exceptional to find flowers which are relatively conspicuous during the later part of the life of the plant, and when found they are apt to be much reduced as compared with the earlier forms. The inflorescence being indefinite, the lengthening of the main stem and branches favors this progressive diminution. Plants that do not exceed 10 to 15^{cm} usually remain simple and are mainly restricted to cleistogamy. Plants taller than this commonly have flowers adapted to pollination by insects, though it must be rare in the smaller flowers, if done at all, when the limb of the corolla is but 3 or 4^{mm} in diameter, as MÜLLER found was the case with the small flowers he mentions.

Cleistogamy begins on stems not more than 2^{cm} high, which may be limited to a single flower at the tip, or perhaps lengthen enough to bear two or three. Flowers will appear on these diminutive stems as early as the larger petaliferous ones on the vigorous plants, the

two forms being synchronous, but on stems under different circumstances. They continue to increase in number on plants of this simple character until the stem ceases to lengthen or becomes mature, various heights being reached, but rarely more than 2^{dm}. Other slender and normally simple stems, usually not flowering at all till 12 to 15^{cm} high, bear as a rule small open flowers, and may continue to do so for some time, growing on till by progressive diminution of size the cleistogamous stage is reached. But the plants are apt to branch when 15 to 20^{cm} high, and bear the larger flowers on the main stem and branches that successively form. Two or three of these stouter stems often spring from the same root, forming a small cluster, with larger and more abundant radical shoots, the plant in all its features showing its greater vigor. In BRITTON and BROWN'S *Illustrated flora*, the statement is made under *L. canadensis:* "A dwarf form with no corolla is frequent." This evidently refers to the cleistogamous form. But the stage with no corolla is not confined to the dwarf plants. It was not on such that I noticed them at first, but on those which varied in height. In the dune region they may rise to 6^{dm} and bear the closed flowers in the later stages of growth. As the taller forms often branch quite freely, great numbers of capsules are borne, developing on the principal stem and branches at the same time and long after the ripened capsules lower down have opened and dropped their seeds. Since the branches ascend rather sharply, frequently rising well up to the level of the primary axis, a copiously branched plant, sometimes with fifteen to twenty members, may result. These have a bushy appearance, but they all produce the closed flowers before the plant dies, and manifest its ability to bear vast numbers of seeds.

The length of the corolla in the closed flowers is 1.2 to 1.6^{mm}. It is tubular, or sometimes slightly funnelform, but owing to the quite rapid growth of the ovary soon becomes enlarged at the base, and when pushed off is shaped more like an inverted funnel; or, if enlarged at the same time above, it has somewhat the form of an hour-glass. The limb is slightly irregular, the two-lobed upper lip being higher than the three-lobed lower, and overlapping it in the bud. In the illustration *fig. 1* shows an ordinary chasmogamous flower, *fig. 2* a cleistogamous flower, both enlarged five diameters, *figs. 3* and

4 a cleistogene corolla enlarged ten diameters, that of *fig. 4* displayed, the division being made between the two lobes of the upper lip. The style and stigma, if represented, would be between the two pairs of stamens as in the ordinary flowers, the stigma in this case closely pressed by the anthers when the parts are in place. The four stamens are apt to be present, and slightly didynamous. Sometimes a small protuberance at the base of the tube represents the spur. In the smaller chasmogamous forms, this may be reduced to a short sack or tooth, and usually decreases in size as the other parts diminish. But in some cases it remains relatively longer in comparison with the lessened tube and limb. I found no case of a cleistogene without a corolla. But as in other cases of cleistogamy it is easy to imagine the flowers represented by the calyx and the essential organs of fructification.



FIGS. 1–4.—*Linaria canadensis.* Fig. 1, petaliferous flower ×5; *fig. 2*, cleistogene flower ×5; *fig. 3*, corolla of cleistogene flower ×10; *fig. 4*, the same, displayed, ×10.

Depauperate as well as larger forms with cleistogamous flowers have been noted by others. RYDBERG, in his *Flora of the Black Hills*, mentions a *L. canadensis* collected at Custer as being "slender and depauperate, apparently with cleistogamous flowers. The same has also been collected in Nebraska."[8] The month given for RYDBERG'S collection is August. J. R. WEBSTER records cases observed by him at Milton, Mass., August, 1898. The plants were again noticed the next year, being "examined almost daily from April to October, and were seen to produce flowers abundantly which were all cleistogamous." They were observed by him in other localities, in which were also racemes which bore in addition fully developed flowers.[9] As the plants at Milton are said to reach the height of

[8] RYDBERG, P. A., Contrib. U. S. Nat. Herb. **3**:517. 1896.

[9] WEBSTER, J. R., Cleistogamy in *Linaria canadensis*. Rhodora **2**:168. 1900.

twenty to twenty-four inches and to produce branched racemes, "some of which were a foot or more in length," they were evidently of the larger forms, such as grow in the dune region in Indiana. But in their lack of chasmogamous flowers, they are somewhat different from any I have noticed there. The cases alluded to in his article as seen in "other localities" are more like those I have described. T. S. BRANDEGEE has likewise observed the plant about San Diego, Cal., "bearing cleistogamous flowers on the lower part of the main and the whole length of many side branches,"[10] apparently more like the larger forms here. Yet these statements from different sources indicate that the plant varies somewhat in its behavior in the respective localities, due perhaps to different environment.

Cleistogamy in Linaria is not confined to our wild toad-flax. It is one of the forty-four genera given in an article by KUHN in 1867 as producing examples with flowers of this character.[11] This list has been much increased since that date. KUHN does not give the name of the species, but probably refers to *L. spuria* Mill., whose peculiar florescence was described by EUGENE MICHALET in 1860.[12] MICHALET gives it as an example of a plant bearing hypogeous flowers. "These flowers," says DARWIN, "may be ranked as cleistogamic, as they are developed, and not merely drawn, beneath the ground."[13] It also has another peculiarity, according to MICHALET "infrequent in an annual plant," that of producing hypocotylous buds. Its lower leaves are opposite and much crowded. Two kinds of branches spring from their axils. Some of these, strong and often much elongated, spread over the surface of the ground; others short, slender, and much twisted, with small squamose leaves, gather in a bunch above the collar of the root, "all with a manifest tendency to bury themselves in the ground, especially the small hypocotylous branches which sometimes appear." Under suitable conditions they may penetrate the ground to the depth of 2 cm. On account of the

[10] BRANDEGEE, T. S., Cleistogamous flowers in Scrophulariaceae. Zoe **5**:13. 1900.

[11] KUHN, M., Einige Bemerkungen über Vandellia und der Blütenpolymorphismus. Bot. Zeit. **25**:67. 1867.

[12] MICHALET, E., Sur la floraison des Viola . . . . et du *Linaria spuria*. Bull. Soc. Bot. France **7**:465. 1860.

[13] DARWIN, C., Different forms of flowers 325. 1877.

pressure to which they are subjected, the flowers are poorly developed, but otherwise show nothing peculiar in their structure. The corolla is crumpled and deformed, but "preserves even its natural color, with the two brown spots on its upper lip." The calyx alone loses its color. Fructification takes place regularly. MICHALET adds that the phenomenon can be produced at will by heaping earth around the lower part of the plant, this not interrupting the flowering of the covered portion. The treading of cattle and the pressure of wheels bring about the same result. As this plant of Europe and northern Africa is now introduced into this country, being, according to GRAY'S *New manual*, "occasional on ballast or waste grounds," an opportunity is provided for observing its behavior here. Another species of north Africa, *L. agglutinans* Pomel. var. *lutea*, belongs to this class of hypogeous plants, as observed by L. TRABUT in Algiers. It has cleistogamous flowers on shoots which spring from the stem near its base and ripen their fruit underground.[14]

III. RELATIVE ADVANTAGES OF THE TWO MODES

It is a distinct advantage to a plant growing under the conditions of *Linaria canadensis* to prolong its period of fruiting with a lessened demand on its supply of food. The environment is xerophytic. At Oregon it was the southern slope of a steep hill, fully exposed to the light and heat of the sun. The soil was sandy, and soon parted with any moisture that was supplied by rains and dews. The conditions in the dunes are similar, the slopes of sand hills or along paths and roadways in open sunny spots. The growth is usually scattered, though many plants may form a community, but the ground is not covered with a dense mat or bed as it commonly is by *L. vulgaris*. The slender stems provide but meager shade for the ground about their roots. In the early part of the season, or if it continues wet, the radical shoots form rosettes around the base of the stems, which protect the roots to some extent. In ordinary seasons these soon wither, and they may not be formed at all on plants which spring up later, being minute or wanting as in the smaller early plants. It is also a species poorly adapted to competition. When pressed by perennials, or by plants disposed to form a close stand, it soon disappears. And

[14] KNUTH, Handbuch der Blütenbiologie **32**:113. 1905.

the plants associated with it, even if perennials, are not very sturdy competitors, but mostly of gregarious habit also. At Oregon they were chiefly *Lechea tenuifolia*, *Talinum teretifolium*, *Selaginella rupestris*, *Silene antirrhina divaricata;* in the dunes of Indiana, *Krigia virginica*, *Arabis lyrata*, *Viola pedata*, *Polygonella articulata*, and *Festuca octoflora*. But to whatever extent the time of fruit-bearing may be prolonged by cleistogamy, it is comparatively short in such habitats. It starts early, when there is little competition, and being an annual or fall-biennial, soon accomplishes its life-work.

That the cross-pollination of the earlier and larger flowers of *L. canadensis* must also be much to its advantage, in increase of vigor and productiveness, is evident from the nature of this process. This was clearly proven by DARWIN in his experimental work with cross- and self-fertilized plants. Of two beds of *L. vulgaris*, raised respectively from self-fertilized and crossed seedlings, those of the latter were seen to be much more vigorous. This led him to trials with this and other plants, the results of which are given in his book upon this subject. The case of Linaria needs only to be cited. As showing the vigor, "the naturally crossed plants were to the spontaneously self-fertilized plants in height, at least as much as 100 to 81." In regard to fruitfulness similar results came from the two modes of treatment, that of allowing or preventing the visits of bees. "The number of seeds in the capsules on the exposed plants to the average number in the finest capsules on the protected plants was as 100 to 14," or as expressed by him in a summary of plants so treated, the self-fertilized were "extremely sterile."[15] KNUTH is even more emphatic in stating that though self-pollination is possible and can occur spontaneously in *L. vulgaris*, it is of little consequence or without result.[16] In cases of this kind, where pollination from without and within takes place simultaneously, HERMANN MÜLLER thinks it probable that the former preponderates in its effects, and that the desired result is secured in this way.[17]

[15] DARWIN, C., Cross and self-fertilization in the vegetable kingdom 88, 89, 363. 1877.

[16] KNUTH, Blumen und Insekten auf dem nordfriesischen Inseln 111. 1894.

[17] MÜLLER, Befruchtung der Blumen 279.

IV. LIGHT AND HEAT AS FACTORS IN CLEISTOGAMY

The behavior of *Linaria canadensis* led to the conclusion that the gradual diminution in size of flowers was connected with the increase of heat, and perhaps of the light, to which they are exposed. Taking the larger plants as typical examples, the two features are in inverse proportion. This might be taken as a coincidence, but it seemed to be explained better as a coordination, and more in harmony with observations and experiments by others. In 1874 BOUCHÉ called attention to his observations that the diminution in the size of flowers and the production of cleistogamy depend in some plants on the decrease or increase of heat, in others on the decrease or increase of the length of the day. In the behavior of some, of which *Vinca rosea* L. is an example, the light acted favorably, the largest flowers being formed during the longest days, the smallest during the season of the shortest days. This seemed to depend on the light, since with a higher temperature after the longest days had gone by the decrease went on. In other cases cited by him, the decrease in size and production of cleistogamy are coordinated with the increase of heat and light, as if these acted unfavorably. As examples of this are the malvaceous plants, *Pavonia hastata* Spr. and *P. praemorsa* Willd. They begin to bloom at the end of May and show the phenomena of diminution and cleistogamy until the autumnal equinox, after which the flowers gradually increase in size till the beginning of winter or close of their floral season.[18] The case of the pavonias more closely accords with that of *L. canadensis*, as far as the floral season of the two coincide. But since, according to BOUCHÉ, the effects are not uniform, and may even lead to opposite results with different plants, there must be something in the plants themselves which causes the different response, or other environmental conditions must be taken into account. In the case of Linaria, I had associated it chiefly with the increase of heat which ordinarily occurs in summer, and the consequent diminution or more rapid removal of the moisture from the soil of such localities as the plants frequent. The equilibrium between absorption, either from the air or ground, and transpiration is disturbed. The smaller or cleistogamic flower, requiring less food, permits a husbanding of resources for the production of seed.

[18] BOUCHÉ, Gesells. naturf. Freunde 90, 91. 1874.

The vitality of the plant is lessened, but its ability to bear seed in abundance still remains. Economy in productive power results in a prodigality of the means to perpetuate. The waste, seeming or actual, is seen in the countless numbers of seeds which never have a chance to germinate. The scattered plants which annually appear show the need of this productiveness in order to obtain a few that can overcome the adverse conditions.

Aside from any effect which the increase of heat and light may have upon a plant in augmenting transpiration, and thereby making it advantageous to diminish the exposed surface, it is plain that the essential organs of reproduction are withdrawn from such effects far more in cleistogamy than in chasmogamy. As the name implies, these organs are hidden. But there is also a further tendency in many cases of cleistogamy to withdraw the perianth, or protective organs, from the direct effect of the sun's rays. *L. canadensis* is an example of the former tendency, *L. spuria* and *L. agglutinans* of the latter. These two species, as already stated, bend their peduncles down to produce their flowers or perfect their fruit beneath the surface of the ground. Other well-known examples of this are the milkworts, *Polygala polygama* Walt. and *P. paucifolia* Willd., bearing their flowers of this kind on subterranean runners. In the violets, where cleistogamy is so prevalent, the peduncles of the summer (usually apetalous) flowers are generally much shorter than those of the large petaliferous blossoms in spring. The flowers are more or less withdrawn from the light and shaded by the much enlarged leaves of the summer growth, or they may be borne on stems so shortened or declined as to be hidden under fallen leaves or buried in soft humus. The production of the closed flowers under such conditions may be due to a diminished intensity of light, as far as this has a bearing on them. Experiments like those of VÖCHTING show that the perianth of flowers is affected by decrease of light more than the reproductive organs. Chasmogamous flowers may be made cleistogamous in this way. The violets are quite variable in their relations to light, many of them being on the borderland between shade-loving and light-loving plants. The majority of our wild species bear their petaliferous flowers in the earlier part of their season of activity, those of the woods before they are strongly

shaded by the leaves of the trees and the taller plants of the forest floor, those of the field or open places before the grass or other growth overtops them. Their period of cleistogamy occurs when they are not subject to the strongest light. The one exposed to the greatest intensity of light, *Viola pedata* L., differs from most members of the genus in not having such flowers. Its season of blooming as well as environment correspond to those of *L. canadensis* when bearing its largest flowers. As a perennial, the violet has the advantage of drawing upon a supply of food stored in its much thickened root-stock. When this is diminished or too much exhausted, it goes on with the production of the enlarged summer-leaves, and by them elaborates another supply of food for storage. This may be a good explanation of its lack of the cleistogamy so general among its kindred, since it does not seem adequate to the work of bearing flowers and perfecting seed while producing the food for the future need of a xerophytic perennial. Under diminished temperature and favorable conditions of moisture its work of bearing petaliferous flowers may be resumed in late summer and autumn, but they are mostly smaller and much less developed than those of spring. *V. lanceolata* L. is also a species frequent in our dune region. It is a light-loving plant, often greatly exposed in the open sandy border of sloughs, but being hygrophytic has a supply of moisture on which to draw. Hence it passes its summer stage in the production of cleistogamous flowers, which continues long after that of the petaliferous has ceased. Yet it partakes of the general tendency among the violets, that of bearing them on shorter, more hidden stems, with the additional habit of producing them on stolens close to the ground. But *L. canadensis*, being an annual subject to xerophytic conditions, cannot draw on such resources as these two violets have. The development of its cleistogamous flowers evidently depends on its relations to heat and moisture more than on those of light.

V. DEGENERACY IN FLOWERS OF LINARIA

In *L. canadensis* is found an example of a plant passing through decadent stages to the condition of cleistogamy. The slight irregularity of limb and the occasional remnant of a spur show degeneracy, even if the smaller and varying intermediate forms of flowers were

not present. It has already been stated that MÜLLER looked upon *L. minor* and *L. arvensis*, and small-flowered species of Vicia, as examples of plants which had descended from those adapted by their floral structure to pollination by insects. In the plant we are considering, this process is epitomized. Pollination by the help of insects takes place in flowers of an inflorescence which gradually undergoes such changes in a single season as to preclude it. The process of reduction is seen in actual working, and it may be that such flowers, rather small at best, are on the way to a stage where visitation by insects will cease. Yet one cannot regard the explanation as entirely valid. By the very principle of adaptation here invoked, the opposite might come true; that is, visits by insects, frequently repeated and continued for a long period of time, would finally produce flowers better suited to their work. Irregularity of floral structure is regarded as such an adaptation, and to some extent has been explained by it. A causal relation between the two is traced. In DARWIN'S list of genera with cleistogamic flowers, thirty-two of the fifty-five he gives have the flowers in their most advanced stage irregular. He says that this "implies that they have been especially adapted to fertilization by insects."[19] Without pressing such explanations too far, it is seen in the case of the wild toad-flax that provision for cross-fertilization is made in the structure of flowers borne simultaneously with the cleistogamous, or at an earlier date, on the same plant. In this there is insured to the species the present means of invigorating its life, the primary benefit to be derived from it, whether it be a waning or waxing advantage.

CHICAGO

[19] DARWIN, C., Different forms of flowers 339.

CURRENT LITERATURE

MINOR NOTICES

Botanical expedition to southern Brazil.[1]—The recently published volume on the results of the botanical expedition of the Royal Academy of Science of Vienna to southern Brazil in 1901 contains an account of the Pteridophyta and Anthophyta by Professor R. von Wettstein in collaboration with several prominent specialists. The conditions under which the expedition was undertaken, the personnel of the exploring party, the detailed itinerary, and the general physical features of the country visited are briefly set forth in the *Einleitung* and *Reisebericht*. The major part of the volume embodies the taxonomic results of the expedition; the larger families treated and the cooperating botanists are as follows: the Filicineae by H. Christ, Orchidaceae by O. Porsch, Gramineae by E. Hackel, Melastomaceae by C. Rechinger, Cyperaceae by E. Palla, Malpighiaceae by C. Kralik, Bromeliaceae by C. Mez, Sapindaceae by L. Radlkofer, Verbenaceae by A. von Hayek, Amarantaceae by A. Heimerl, Gesneriaceae by K. Fritsch, and the Eriocaulonaceae by W. Ruhland. Several smaller families are also included. More than 1300 species are recorded from the various groups thus far elaborated, and of this number nearly 100 are new to science.

The new species are fully characterized, and the descriptions are mostly in Latin; the author of the Cyperaceae, however, has unfortunately chosen to describe the new species of this family in German, thus marring somewhat the uniformity of the work as a whole. The text is supplemented by numerous illustrations, and certain orchids are beautifully portrayed in color. The publication represents the work of eminent specialists and forms a reliable and valuable addition to the taxonomic literature pertaining to the flora of South America.—J. M. Greenman.

Vegetation of Java and Sumatra.—The first and second parts of the seventh series of Karsten and Schenck's now well-known *Vegetationsbilder*[2] is devoted to a dozen plates (with descriptive text) representing the plants of the volcanic regions of Java and Sumatra, and especially the reoccupation of those areas which have been at one time or another devastated by the erupted solid, liquid, or gaseous materials. Among others are three views from Krakatoa. This section by Dr. Ernst sustains the high standard of the work.—C. R. B.

---

[1] Wettstein, R. von, and Schiffner, V. Ergebnisse der botanischen Expedition der kaiserlichen Akademie der Wissenschaften nach Südbrasilien 1901. I. Band. Pteridophyta und Anthophyta unter Mitwirkung zahlreicher Fachmänner herausgegeben von R. von Wettstein. Erster Halbband. Denkschr. Math.-Nat. Kl. Kais. Akad. Wiss. **79**:1–313. *pls. 26. 1 map. figs. 12.* 1908.

[2] Karsten, G., and Schenck, H., Vegetationsbilder. 4to. VII. Reihe, Heft 1, 2. Ernst, A., Die Besiedelung vulkanischen Bodens auf Java und Sumatra. *pls. 1–12.* Jena: Gustav Fischer. 1909. *M*5.

NOTES FOR STUDENTS

Inheritance of sex.—CORRENS[3] has continued his studies on gynodioecious plants in order to discover what determines the sex of the flowers on the gynomonoecious individuals, and the sex of the two classes of individuals belonging to such species. He finds that the curve of frequency of hermaphrodite flowers in *Saturcia hortensis*, instead of presenting two modes, as previously reported by him, one in the mid-season and one at the end of the season, has only a mid-season mode. The mode which appeared at the end of the season was due to the repeated counting of flowers which remained open more than one day.

During the middle of the season no flowers open on the second day, but late in the season the petals seem to be more resistant, and climatic conditions are less severe, so that the same flowers were unwittingly counted several times. When each flower is marked as it is counted, it is found that the proportion of hermaphrodite flowers continues to fall till the end of the season.

He also tested the effect of environmental conditions upon the percentage of hermaphrodite and female flowers produced on plants of Satureia from day to day, and noted the position occupied by each kind of flower on the plant. The results show that poor nutrition, whether the result of poor soil, insufficient illumination, or disadvantageous position on the plant, lessens the proportion of hermaphrodite flowers, and under the combined influence of both poor soil and poor light, only 13 per cent. of hermaphrodite flowers were produced as compared with 79 per cent. produced under normal conditions of culture. However, the general features of the curve of frequency of the hermaphrodite flowers remain the same. With high nourishment the curve for the hermaphrodite flowers falls much more gradually toward the end of the season, though during the early part of the season it is not essentially modified.

It was found that different strains of Satureia show marked differences in the actual percentage of hermaphrodite and female flowers, but that in each case the general features of the curve of frequency are the same. The conclusion is reached that whether hermaphrodite or female flowers are to be produced by a gynodioecious individual is dependent upon nourishment in its widest sense. The same general results may be demonstrated in Geranium, *Silene inflata* and *S. dichotoma*, *Plantago lanceolata*, Scabiosa, Knautia, and Echium.

DARWIN had observed that a single hermaphrodite plant of *Satureia hortensis* was "rather larger" than the female plants of the same species, and in an earlier paper CORRENS had apparently substantiated this observation, without realizing the possibility that some of the plants classed as female might be hermaphrodite plants, rendered *apparently* female by poor nutrition. He undertook to determine the relative weights of these two classes of plants with a more careful analysis of the material. The results show that there is no difference in weight between the

[3] CORRENS, C., Weitere Untersuchungen über die Geschlechtsformen polygamer Blütenpflanzen und ihre Beeinflussbarkeit. Jahrb. Wiss. Bot. **45**:661–700. *figs. 11.* 1908.

female and gynomonoecious plants, and therefore the difference in weight which was assumed by DARWIN to be a secondary sexual character has no such significance.

CORRENS has also investigated[4] the percentage of female and hermaphrodite plants in *Plantago lanceolata* under conditions of controlled pollination, and has shown that while this plant, like Satureia and Silene, shows a marked tendency for each sex to reproduce its own kind, nevertheless there is considerable variation in this regard in individuals of both sexes. By pollinating the same female individual with different hermaphrodite individuals, and by pollinating different females with pollen from the same hermaphrodites, it was shown that the proportion of hermaphrodite offspring and of females is so related in each case that they may be readily calculated, after once the strength of the hermaphrodite tendency in the pollen-parent and of the female tendency in the pistil-parent is known. In other words, each individual appears to have a different strength of these two sex-tendencies and to produce germ-cells of two kinds with respect to these tendencies, the number of each kind of germ-cells produced being perhaps roughly proportional to the strength of the sex-tendencies in the parents.

The theory that the germ-cells of *Plantago lanceolata* do not themselves vary in their tendency to produce a certain sex, but that they are definitely either female or hermaphrodite, puts these plants into the class known as ever-sporting varieties, and makes this paper also a valuable contribution to the study of this recognizedly difficult type of inheritance.

The assumption that each germ-cell is definitely female or hermaphrodite and that the female is dominant allowed the prediction of the actual numbers of each sex produced in the different experiments with a fair degree of accuracy.

Several other papers have recently appeared dealing with the question of sex-determination. DONCASTER and RAYNOR[5] found that in crosses between *Abraxas grossulariata*, a common English moth, and its rare variety *lacticolor*, reciprocal crosses are not equal, for when a *lacticolor* female is crossed with a *grossulariata* male, no *lacticolor* offspring are produced, and males and females are all *grossulariata;* but when the reciprocal cross is made, all of the females are *lacticolor* and all of the males *grossulariata*. To explain this strange situation the authors assumed that sex is a Mendelian character, and that the *lacticolor* character is coupled with the female determinant. It was assumed that both male and female individuals are heterozygous with respect to sex. In this regard their interpretation differed fundamentally from that of CORRENS, who assumed that in the case of *Bryonia alba* × *dioica* and other dioecious plants the female sex is homozygous, and the male heterozygous.

BATESON and PUNNETT,[6] in discussing DONCASTER'S results, show that a

[4] CORRENS, C., Die Rolle der männlichen Keimzellen bei der Geschlechtsbestimmung der gynodioecischen Pflanzen. Ber. Deutsch. Bot. Gesells. **26a**:686–701. 1908.

[5] Proc. Zoöl. Soc. **1**:125. *pl. 1.* 1906.

[6] Science N. S. **27**:785. 1908.

simpler explanation may be given by assuming that the male is homozygous and the female heterozygous with respect to sex, and that there is a repulsion between the determinant for the *grossulariata* character and that for the female sex. These assumptions fit all of the facts brought to light in the crosses of Abraxas. This point of view has been briefly restated by DONCASTER[7] in a report to the Evolution Committee of the Royal Society, where a summary of the matings and their results is given. Another case has been reported which seems to correspond very closely with that of Abraxas. The "cinnamon" canaries, i. e., those having plumage of a brownish tint, have pink eyes when hatched. The green canary has black eyes. Misses DURHAM and MARRAYAT[8] have found that when a pink-eyed hen-canary is crossed with a black-eyed cock, all the young of both sexes are black-eyed. The reciprocal cross shows all the male offspring black-eyed, while all the pink-eyed offspring are females, though a few black-eyed hens may occur. The latter are as yet unexplained, but there seems to be little doubt that this cinnamon canary will find an explanation essentially like that given for Abraxas.

Great advances have likewise been made in the study of the determination of sex from the cytological side, mainly through the work of MCCLUNG, STEVENS, MORGAN, WILSON, and their students. In nearly one-hundred species of insects belonging chiefly to the Hemiptera and Coleoptera, it has been found that there are definite chromosomal differences between the male and female, and that the odd chromosomes, or "accessory" chromosomes as they were called by MCCLUNG, are so distributed at the time of the reduction division that all the female germ-cells are alike, while the male germ-cells are of two kinds. The chromosome group of one of these two types of male germ-cells is like that of the egg-cell, and when such a sperm fertilizes an egg, a female zygote is produced. The other type of sperm has a chromosome group unlike that of the egg, and fertilization with such a sperm produces a male zygote.

An excellent résumé of this work and a discussion of the entire problem of sex-heredity is given by WILSON,[9] who has been most prominently engaged in these new discoveries. Showing how experimental breeding and cytology supplement each other, WILSON lays emphasis upon the necessity of bringing different methods of scientific investigation to bear upon difficult scientific problems like this, and the undesirability of depending upon any single method. In this day of intense specialization this is more fundamental than ever before. Similar cooperation would even improve general discussions of a subject which is being developed simultaneously by different methods, for it has become difficult for anyone to give an ade-

---

[7] DONCASTER, L., On sex-inheritance in the moth, *Abraxas grossulariata* and its var. *lacticolor*. Reports to the Evolution Committee **4**:53–57. 1908.

[8] DURHAM, F. M., AND MARRYAT, D. C. E., Note on the inheritance of sex in canaries. Reports to the Evolution Committee **4**:57–60. 1908.

[9] WILSON, E. B., Recent researches on the determination and heredity of sex. Science N. S. **29**:53–70. 1909.

quate treatment of such a subject. WILSON's discussion would have been rendered simpler and more cogent, if he had grasped the logical homologies between plants and animals now generally accepted by students of genetics. He does not seem to appreciate the fact that it is the *gametophyte* of plants which finds no clear homologue in animals, and so fails to assign a proper degree of importance to the parallelism between the sporophyte and the animal body or soma. Again, if he had been more familiar with the most recent developments of Mendelian theory he would have found that the discoveries in these insects are in perfect accord with Mendelian heredity. Instead of this, he presents as a "naïve assumption" what is now generally held by the students of Mendelism, and known as the "presence and absence hypothesis," the assumption being that the heterozygote and the positive homozygote differ from each other in that the former has an unpaired unit, X, and the latter a pair of units of the same kind, XX.

CASTLE[10] takes up this question and shows the perfect agreement between the results of these cytologists, and the requirements of the presence and absence hypothesis in Mendelian heredity. In CASTLE's exceedingly clever discussion an attempt is made to harmonize the apparently antagonistic results with Bryonia, the Hemiptera, and Coleoptera on the one hand, and those with Abraxas and the cinnamon canaries on the other, by assuming that in all cases the female possesses one more unit than the male, this unit being called by WILSON the "X-element." Bryonia, and all of the insects whose male germ-cells have been found to be of two kinds, represent a condition in which the male is a heterozygote, and the female is a *positive homozygote*. CASTLE calls this a "dominant female," but this is obviously a misleading terminology, for if the female were *really dominant* the heterozygote would also be a female and there could be no males. In Abraxas, and the cinnamon canaries, and, as suggested by CASTLE, perhaps also in the pheasant, the female is heterozygous and the male is assumed to be a *negative homozygote*, i. e., wholly lacking the X-element. This is the most promising attempt yet made to bring all the recently discovered facts of sex-heredity in dioecious animals and plants under a single hypothesis.

CASTLE attempts further, by an extension of the same hypothesis, to account for the fact that male animals usually possess more characters than the female. He supposes that these added male characteristics are associated with or produced by a Y-element, the "synaptic mate" of the X-element. He also suggests that progressive evolution may have taken place by the appearance and development of such a "synaptic mate" for the X-element, but this, and also the attempt to explain orthogensis on the same basis, is carrying hypothesis rather far from empirical knowledge.

There can be no question that the problems of sex possess many intricacies and difficulties yet to be solved, but the results of these investigations both from the experimental and the cytological side have placed these problems on a new

[10] CASTLE, W. E., A Mendelian view of sex-heredity. Science N. S. **29**:395–400. 1909.

basis, and opened up many possibilities and suggestions for their further investigation. All of the results seem to point to the truth of the view that sex is predetermined in the germ-cells, and that therefore it cannot be modified by environmental conditions except, of course, by such conditions, as yet unknown, as are capable of producing mutations.—GEORGE H. SHULL.

Current taxonomic literature.—N. L. BRITTON and J. N. ROSE (Jour. N. Y. Bot. Gard. **9**:185–188. 1908) have proposed a new genus (*Carnegiea*) of the Cactaceae. The genus is based on the well-known *Cereus giganteus* Engelm., and contains but the one species. H. PITTIER (Contr. U. S. Nat. Herb. **12**:171–181. 1909) has published 8 new species of flowering plants from tropical America. The descriptions are supplemented by two full-page illustrations and several text-figures; the types are deposited in the U. S. National Herbarium. A. THELLUNG (Bull. Herb. Boiss. II. **8**:913, 914. 1909) records 3 new varieties of *Lepidium pubescens* Desv. from South America. F. STEPHANI (*ibid.* 941–972) has published 43 new species of the genus Mastigobryum from various localities. G. BEAUVERD (*ibid.* 986–988) has published a new Eriocaulon from Brazil and also a new species of Tulbaghia from the Transvaal; the same author (*ibid.* 993–1007) records 8 new species and one variety of Nothoscordum from Uruguay and gives an analytical key to the Uruguayan species. E. G. PARIS (Bull. Soc. Bot. France IV. **8**:Mém. 14, pp. 1–66. 1908), under the title *Florule bryologique de la Guinée française*, has published 6 new species of mosses. F. GAGNEPAIN (*ibid.* Session extr., pp. xxxvi–xliii) has published 4 new species of Zingiberaceae and a new genus (*Ataenidia*) of the Marantaceae from Africa, and also a new species of Calathea native of Indo-China. G. BONATI (*ibid.* 509–515, 537–543) describes 25 new species and 4 new varieties of scrophulariaceous plants from Indo-China. F. GAGNEPAIN (*ibid.* 521–527, 544–548) has published 12 new species of Asiatic plants belonging to the Bixaceae and Pittosporaceae. F. KRÄNZLEIN (Fedde Rep. Nov. Sp. **6**:18–23. 1908) publishes 8 new species of Orchidaceae from Bolivia. WOLFF (*ibid.* 24) records a new Eryngium from Bolivia. O. BECCARI (*ibid.* 94–96) records 4 new species of palms from the Antillean region. W. WANGERIN (*ibid.* 97–102) has published 13 new species of the genus Cornus, chiefly from China. E. HACKEL (*ibid.* 153–161), under the title *Gramineae novae V*, has published 8 new species and 5 varieties of grasses from Bolivia. E. L. GREENE (*ibid.* 161) records a new species of Argemone from New Mexico. E. ROSENSTOCK (*ibid.* 175), in an article entitled *Filices novae IV*, has published 4 species and one variety of ferns as new to science. B. P. G. HOCHREUTINER (Ann. Conserv. et Gard. Genève **11–12**:136–143, reprint pp. 1–8. *pls. 1, 2.* 1908) has published a revision of the genus Adansonia in which 8 species are recognized, one of which, *A. Stanburyana* from northwestern Australia, is proposed as new to science. G. A. NADSON (Bull. Jard. Imp. Bot. St. Petersb. **8**:113–121. *pl. 1.* 1908) describes a new microorganism (*Rhodosphaerium diffluens*) from the Caspian Sea; the systematic position of the plant according to the author is "an der Grenze zwischen Algen und Bakterien." C. FERDINANDSEN and O. WINGE (Bot. Tids-

skr. **29**: 1–25. *pls. 1, 2.* 1908) have published 19 new species of fungi; these are based on collections made in the Danish West Indies by C. RAUNKIAER during the years 1905 and 1906. W. FAWCETT and A. B. RENDLE (Journ. Botany **47**: 3–8. 1909) have published diagnoses of 12 new species of orchidaceous plants from Jamaica; these are preliminary to a monograph of the orchids of Jamaica. E. ULE (Engl. Bot. Jahrb. **42**: 191–238. 1908), in collaboration with different specialists, under the title *Beiträge zur Flora von Bahia I*, has published 75 species and one variety as new to science; these are referred to families in the Engler sequence from the Bromeliaceae to the Araliaceae and include the following new genera: *Sincoraea* and *Cryptanthopsis* (Bromeliaceae), *Heptocarpum* (Capparidaceae), and *Itatiaia* (Melastomaceae). E. KOEHNE (*ibid.* Beiblatt 97: 47–53) records 5 new species and 4 new varieties in the Lythraceae from South America, Africa, and Siam. Different authors (Kew Bull. **1908**: 432–441), under the title *Diagnoses Africanae XXVI*, have published 19 new species and one variety of African angiosperms, including 2 new genera (*Aristogeitonia* and *Androstachys*) of the Euphorbiaceae; also (*ibid.* 445–451) in *Decades kewensis: Decas LI*, 10 new species are described from various localities. E. L. GREENE (Leaflets Bot. Obs. & Crit. **2**: 1–24. 1909) proposes a series of 60 new species and 3 new varieties of flowering plants, chiefly from western United States. J. BORNMÜLLER (Mitt. Thür. Bot. Ver. **23**: 1–27. 1908), in continuation of his contributions under the title *Novitiae Florae Orientalis*, has published 23 species as new to science, of which 17 belong to the genus Astragalus. A. SCHERFFEL (Ber. Deutsch. Bot. Gesells. **26a**: 762–771. 1909), proposes a new genus (*Asterococcus*) for the alga hitherto known as *Pleurococcus superbus* Cienk. N. L. BRITTON (Bull. N. Y. Bot. Gard. **5**: 311–318. 1909), in continuation of his studies on the flora of the Bahamas, has described 6 new species of flowering plants. F. S. EARLE (*ibid.* 373–451), under the title of *Genera of the North American Gill Fungi*, recognizes 147 genera for North America, and of these 38 are designated as new.—J. M. GREENMAN.

Hybrids of Oenothera.—DEVRIES has recently published several remarkable papers on hybridization in Oenothera. The results concern a new type of hereditary behavior, which is of great interest, showing as it does that we are only on the borderland of knowledge in these fields. Such discoveries, which open new vistas for the future, are of special value as a stimulus to research. The first of these papers appeared in this journal[11] and announced the discovery of what are called twin hybrids, and a later paper[12] dealt with triple hybrids. In certain cases, when one of the wild species of the Onagra group is crossed with *O. Lamarckiana* or one of its mutants, two types are produced in about equal numbers, both of which breed true, the same types appearing in the different crosses. These types DEVRIES calls *O. laeta* and *O. velutina*. In the case of *O. scintillans* and *O. lata*

[11] DEVRIES, HUGO, On twin hybrids. BOT. GAZETTE **44**: 401–407. 1907.

[12] ———, On triple hybrids. BOT. GAZETTE **47**: 1–8. 1909.

triple hybrids are produced—in addition to *O. laeta* and *O. velutina* a third type resembling the mother (*O. lata* or *O. scintillans*), but in its special marks intermediate between its parents.

The twin hybrids of *O. nanella* have been worked out most completely.[13] *O. muricata* × *O. nanella* produces the two types *laeta* and *velutina*, about 50 per cent. of each. The *laeta* breed true for four generations, but the *velutina* split in the F_2 and all succeeding generations, producing *velutina* and something over 50 per cent. of a form called by DEVRIES *O. murinella*, which is a dwarf *O. velutina* and breeds true. The dwarf character (but not the other *O. nanella* characters), therefore, reappears in over half of each generation. The discoveries of greatest interest follow. *O. velutina* × *O. murinella* gives the same results as *O. velutina* self-pollinated, i. e., over 50 per cent. *O. murinella*. From this the conclusion is drawn that the pollen of *O. velutina* has the same hereditary qualities as that of *O. murinella*. The reciprocal cross gave 100 per cent. *O. murinella* (280 plants). The facts are all explained by assuming that the egg cells of *O. velutina* are of hybrid (heterozygote) nature ($a \times b$), while the pollen bears only the dwarf character (a). On self-pollination *O. velutina* would then give 50 per cent. *O. velutina* ($a \times b$) and 50 per cent. *O. murinella* (a) which breed true. This conclusion is verified by crosses of *O. velutina* and *O. nanella* (since *O. velutina* × *O. nanella* gives 57 per cent. *O. murinella*, and *O. nanella* × *O. velutina* gives 100 per cent. *O. murinella*).

Similarly, *O. laeta* crossed with *O. murinella*, *O. nanella*, or *O. velutina* gives 50 per cent. *laeta* and 50 per cent. dwarfs. Therefore the egg cells of *laeta* are also hybrid (heterozygote) in regard to the dwarf character, although when self-pollinated *laeta* breeds true! The pollen of *laeta* therefore bears the hereditary characters for high stature. This dominates over the hybrid nature of its own egg cells, but is recessive to the egg cells of pure dwarfs. The remarkable situation therefore appears, that the egg cells of both *velutina* and *laeta* behave as heterozygotes, while the pollen of the former behaves as though it carried only the dwarf character, and the pollen of *laeta* appears to carry only the character for high stature.

Another paper[14] shows that the hybrids of *O. gigas* behave differently from those of other mutants. *O. gigas* × *O. Lamarckiana* forms a constant intermediate race. *O. Lamarckiana* × *O. gigas*, *O. gigas* × *O. brevistylis*, *O. gigas* × *O. rubrinervis*, and *O. rubrinervis* × *O. gigas* all give the same hybrid race. *O. lata* × *O. gigas*, however, gives two types, about half intermediate between *O. gigas* and *O. Lamarckiana*, and half intermediate between *O. gigas* and *O. lata*. *O. gigas* crossed with *O. biennis* and *O. muricata* produces intermediate sterile hybrids.

---

[13] DEVRIES, HUGO, Ueber die Zwillingsbastarde von *Oenothera nanella*. Ber. Deutsch. Bot. Gesells. **26a**:667–676. 1908.

[14] ———, Bastarde von *Oenothera gigas*. Ber. Deutsch. Bot. Gesells. **26a**: 754–762. 1908.

Miss LUTZ[15] studied forty individuals of *O. lata* × *O. gigas* and describes a group of hybrids which probably include both the types of DEVRIES, and in addition plants like *O. lata* and like *O. gigas*, having their respective numbers of chromosomes.—R. R. GATES.

Nitrogen fixation by Azotobacter.—KRZEMIENIEWSKI has contributed a paper[16] that seems to throw much-needed light on the problems of nitrogen fixation by Azotobacter in the soil. Perhaps its most valuable feature is the demonstration of the accelerating influence of humus on the process. He finds that Azotobacter in pure cultures in ordinary nitrogen-free media can fix little atmospheric nitrogen, but that the addition of sterile soil or of humic acids or their calcium, potassium, or sodium salts to such solutions multiplies the amount of nitrogen fixed many times. It is interesting to note further that the humus derived from different soils does not yield uniform results, and that artificial "humus" formed by the action of acids on carbohydrates is of little or no value. LIPMAN[17] in this country has anticipated in part some of these results, for he found that the amount of nitrogen fixed by Azotobacter growing in solutions to which different types of soils had been added varied greatly. KRZEMIENIEWSKI further reaches the interesting conclusion, as a result of repeated experiments, that humus does not serve either as a source of nitrogen or of carbon for Azotobacter. He finds that the various nitrogen compounds used in an effort to duplicate the stimulating influence of humus are without such results. When these compounds were used in conjunction with humus they were found to be even decidedly inhibitory in action. Why the humus should thus stimulate growth of Azotobacter he fails to explain, although he seems to have had abundant experimental evidence of the fact. The author was able to demonstrate as much as seventeen milligrams of nitrogen fixed per gram of glucose used in carbohydrate solutions to which humus or humic acids had been added. This is a higher ratio than has been reported by other investigators. He further succeeded in demonstrating by gas analysis for the Azotobacter what was long ago demonstrated for the legume, an actual decrease in the amount of nitrogen supplied to the culture. The organic nitrogen fixed in the culture solution was found at the close of the experiment to check very closely with the amount which disappeared from the air.

The organism is a strict aerobe, neither alcohols, acids, nor hydrogen gas are found as products of metabolism. The ratio $\frac{CO_2}{O_2}$ approaches unity. The temperature optimum for nitrogen fixation is 28° C. Prolonged cultivation of Azotobacter on artificial media the author finds has little influence on its "viru-

[15] LUTZ, ANNE M., Notes on the first generation hybrid of *Oenothera lata* × *O. gigas*. Science N. S. **29**:263–267. 1909.

[16] KRZEMIENIEWSKI, S., Untersuchungen über *Azotobacter chroococcum*. Beij. Bull. Acad. Sci. Cracovie Cl. Sci. Math. et Nat. **1908**:299–1050. *pl. 1.*

[17] LIPMAN, JACOB G., Bacteriological indications of the mineral requirements of soils. Ann. Rep. N. J. State Agr. Exp. Sta. **27**:177–187. 1906.

lence" or ability to fix nitrogen. The contradictory results of other investigations are probably due to the use of different strains of organisms. The differences between these strains are varietal or, possibly, even specific, for cultures from various sources differ considerably in their nitrogen-fixing power.

BEIJERINCK in his work on these organisms proposed a theory of symbiotic activity between Azotobacter and other bacteria. KRZEMIENIEWSKI concludes that BEIJERINCK'S results are to be explained not as due to the presence of the second organism but to the addition of humus to culture solutions.

These studies should serve to emphasize further the importance of soil humus from the standpoint of agricultural practice. In addition to the solution of certain puzzling questions, KRZEMIENIEWSKI has opened several very promising avenues for successful and profitable research in soil bacteriology.—ROBERT E. BUCHANAN.

Mutability and variability.—SCHOUTEN[18] has an extensive account of two years' Oenothera cultures. Seeds from DEVRIES, as well as commercial seeds and "wild" seeds, and rosettes of various species were used. Several new mutants appeared, and a number of interesting combination forms possessing the characters of two types are recorded. The new mutants are *O. blanda* and *O. candelabriformis*, while the combination forms include *O. laevifolia brevistylis*, *O. laevifolia nanella*, *O. rubrinervis brevistylis*, *O. rubrinervis lata*, *O. gigas nanella*, and *O. gigas lata* (?).

He makes the suggestion, which appears rather unlikely, that the *nanella* or dwarf condition in *OO. Lamarckiana*, *laevifolia*, and *gigas* may be due to bacterial action. *O. Lamarckiana nanella* is found to exist in two forms, differing in their bud and flower characters. *O. gigas* is well known to show extremely wide variability, particularly in leaf shape, and an attempt was made to segregate several types, but without success, since the offspring from each showed nearly the whole range of variation.

The occurrence of a number of combination types as mutants in pure strains gives a somewhat different appearance to the mutation phenomena in Oenothera. SCHOUTEN concludes that mutants originate by two different methods: (1) When both the gamete nuclei uniting in fertilization have the constitution of the same mutant. (2) When the gamete nuclei are unlike. Of the latter he classifies two sorts. (*a*) When one gamete nucleus has the constitution of the species and the other that of the mutant. (*b*) When both the gametes have a mutant constitution but not of the same mutant, thus accounting for the combination forms. Further evidence is obtained from the fact that crossing increases the production of mutants.

The third part of the contribution deals with statistical studies of variability in *O. Lamarckiana* and its mutants, and in several wild species. The parts measured include the length and breadth of certain stem leaves selected according to a definite rule; the length and breadth of the petals and sepals of certain selected

[18] SCHOUTEN, A. R., Mutabiliteit en variabiliteit. pp. 196. Groningen. 1908.

flowers; the number of stigma lobes; the length of style, hypanthium, and ovary; length of main stem; number of side branches, etc. A large number of interesting data of variability are here brought together. It is of interest that in nearly all cases the modal number of stigma lobes shows a decrease from 6 or 8 or more to 4 during the season.

The work is an extension of SHULL's[19] statistical studies. SHULL found that in the characters measured, the mutants of *O. Lamarckiana* are more variable than the parent form, and hence that phylogenetically younger forms are probably more variable than the phylogenetically older. This appears to hold for the European *O. biennis* and its mutants *cruciata* and *sulfurea*, but is only partly true for *O. Lamarckiana* and its mutants. *O. gigas* and *O. rubrinervis lata* are more variable than the parent in all the organs examined; but the other mutants are more variable in some characters and less so in others. The coefficient of variability of a mutable species is not markedly different from that of a non-mutable form.—R. R. GATES.

Ontogenetic theory of alternation.—LANG[20] has outlined an interesting theory of alternation of generations which he calls an "ontogenetic" theory, to distinguish it from other theories. The so-called "homologous" and "antithetic" theories are well known, and LANG's work on apogamy in ferns inclined him to accept the former. In fact, the ontogenetic theory is a theory of homologous alternation in its phylogenetic application.

The author starts with the idea that all the cell progeny of a germ cell are potentially similar, and that any one of them might reproduce the organism. The development of a specific organism is regarded as due to the properties of the germ cell and to the conditions under which the germ cell develops. The author, therefore, reaches the conception of a specific cell corresponding to each specific form, to which under normal conditions it gives rise. In plants with a definite alternation of generations, germ cells capable of developing into an organism are met twice in the life-history. The organisms developed by these two cells may be very similar or very different. For example, in Polysiphonia the two resulting organisms are very similar; while in bryophytes and pteridophytes they are very different. To explain the latter case the author recognizes two alternative views: (1) the two germ cells are so different that they necessarily produce different structures; (2) the two germ cells are both specific cells of the same plant, but the conditions of development are so different that the two resulting organisms are very different.

---

[19] MACDOUGAL, D. T., *et al.*, Mutants and hybrids of the Oenotheras. Pub. No. 24, Carnegie Institution. p. 57. *figs. 13. pls. 22.* 1905; Mutations, variations and relationships of the Oenotheras. Pub. No. 81, Carnegie Institution. pp. 92. *pls. 22. figs. 73.* 1907.

[20] LANG, W. H., A theory of alternation of generations in archegoniate plants based upon the ontogeny. New Phytol. **8**:1–12. 1909.

The second alternative is the basis for the proposed ontogenetic theory of alternation, the assumption being that the two germ cells of a life-history, although one is haploid and the other diploid, have potentially the same morphogenetic properties, and under the same conditions would produce similar structures. In the case of the very dissimilar generations of bryophytes and pteridophytes, the causal differences in the conditions of development are expressed broadly as follows: the spore develops free, in direct relation to soil, water, light, etc.; the fertilized egg develops in relation to the body of the sexual generation. The egg is thus removed from all the influences acting on the spore, and is exposed to a new set of nutritive and "correlative" influences proceeding from the parent body. Since each stage in the ontogeny is probably determined by the preceding stage, the general structure of the resulting organism is as fully determined by the relatively short association of egg and gametophyte among pteridophytes, as by their much longer association among bryophytes.

It is evident that this theory regards the two generations of each species as homologous, in that they are developed from germ cells with the same morphogenetic powers. The really important comparisons to make, therefore, are between gametophyte and sporophyte of the same plant; rather than between the sporophyte of ferns and gametophyte of liverworts, for example. The author promises a full discussion of the application of this theory in future papers, but in the present one he gives a very brief outline of its application to ferns, lycopods, and horsetails, comparing the two generations in each group in a most suggestive way. If the chief value of a theory lies in the work it stimulates, this ontogenetic theory should prove of great value, for it opens a large vista of experimental work.—J. M. C.

Morphology of Ruppia.—GRAVES[21] has investigated *Ruppia maritima* in all its aspects, presenting under the title of morphology, not only the gross and minute features of its morphology, but also its anatomy, ecology, and physiology. Such a compendium of statements in reference to a single species is unusual, for in general an investigator in these days is compelled to restrict his attention to one aspect of plants. For this reason, it is impossible for the reviewer to recognize the contributions to knowledge that must be imbedded in the general account, except in a somewhat restricted division of morphology. The general outline of topics is as follows: Morphology of the vegetative organs (46 pp.), in which the structure and function of stem, leaf, and root are described in great detail and contrasted with those of other Potamogetonaceae; Ecology of the vegetative organs (13 pp.), in which the hydrophytic and halophytic adaptations are presented, and the difficult problem of adaptation and heredity discussed; Reproductive organs (18 pp.), in which flower, sporangia, gametophytes, fertilization, and endosperm are described; Embryo; Fruit and seed; Seedling. The paper closes with two summaries and a bibliography of 98 titles.

[21] GRAVES, A. H., The morphology of *Ruppia maritima*. Trans. Conn. Acad. Sci. **14**:59–170. *pls. 1–15. figs. 33.* 1908.

Some of the ecological results are as follows. Ruppia is called a water halophyte, living in salt water that would produce plasmolysis in fresh-water plants, but unable to live in water of the open ocean. The hydrophytic responses of the shoot are the weak and spreading form, the absence of stomata, the production of slime, the numerous air spaces, the lack of mechanical tissue, and the reduction of the vascular system to one axial bundle and two lateral ones in both stem and leaf. The responses of the root are a reduction of the system to small unbranched roots borne singly at the nodes, the presence of air spaces, and the concentric axial bundle. The axial and cortical bundles are thought to be useless hereditary structures.

Some of the facts in reference to the reproductive structures are as follows. The inflorescence is a reduced spadix, and a small spathe is present, which is said to have escaped the notice of investigators almost entirely. In the development of the microsporangium a large archesporial group of cells is differentiated, which later becomes septate. In the development of the megasporangium, usually only one layer of parietal cells is formed, and in one case two functioning mother cells were observed in a sporangium. The count of chromosomes was made in the microsporangium and in the reduction divisions of both gametophytes, and was found to be eight and sixteen. The male cells are produced before pollination, which is accomplished by means of the water. The endosperm is scanty, never being more than a thin layer lining the sac. The proembryo is a filament of three or four cells, the basal one becoming much enlarged to form the suspensor. The three embryo-forming cells produce at first a spherical group of cells, and it is believed that both cotyledon and stem tip are derived from the terminal cell of the proembryo, the two other cells producing the hypocotyl, adventitious root, and primary root, the last organ never functioning.

The paper contains a large amount of information in reference to a very interesting form, and the plates, some of them photomicrographs, reproduce the structures in such a way that every botanist can make his own interpretations. —J. M. C.

Orchid flowers and formative stimuli.—As a product of his visit of three months at the Buitenzorg Garden, FITTING published in the initial number of the new *Zeitschrift für Botanik* an account of his experiments on the effect of pollination and other stimuli upon the postfloration behavior of the flowers of orchids.[22] The tropical orchids, available in great abundance at this garden, are especially suited for experimental study on this point, because the difference in duration of pollinated and unpollinated flowers is sufficient to give opportunity for experimentation with unequivocal results, whether the postfloration processes are autonomous or induced. Of these processes he distinguishes four: (1) premature fading; (2) closure of the stigma and swelling of the gynostemium; (3) swelling of the ovary; (4) greening of the perianth.

[22] FITTING, H., Die Beeinflussung der Orchideenblüten durch die Bestäubung und durch andere Umstände. Eine entwickelungsphysiologische Studie aus den Tropen. Zeits. Bot. 1:1–86. *figs.* 27. 1909.

He was able to induce premature fading by applying most various substances to the stigma: besides their own living pollen, volcanic river-sand, spittle, dead pollen and pollen extract, dead and leached pollen of the same species or of other genera or even of other and remote groups, and extract of gynostemium tissues induced it, and apparently also 5 per cent. saccharose. He was not able to determine what the chemical agent or agents were in these reactions. Wounding the stigma or the tissue at the apex of the gynostemium also caused premature fading. Closure of the stigma and swelling of the gynostemium could be effected by bestrewing the stigma with living or dead pollen of orchids (any genus) or even of Hibiscus, and with the alcoholic extract of pollen. On the contrary, dead pollen and pollen extract had no effect or the very slightest in inducing swelling of the ovary, which occurred only when living pollen germinated on the stigma and its tubes grew into the ovary. The greening of the perianth (peculiar to certain species) appears only when the ovary has previously begun to swell and to turn green.

FITTING considers fading as the end process of floral development, simply released by the pollen stimulus or others earlier than it is autonomously. The stimulus, however, does not merely hasten development; it diverts its course, for a perianth half open and quite incompletely developed may be made to fade in twelve to twenty-four hours by a stimulus which proceeds from the distant stigma. This also offers a new example of the separation of perceptive and reactive regions. The closure of the stigma, etc., appears to be strictly a case of chemomorphosis, but the agent does not produce any effect on the ovary, whose growth and formation of ovules, and so the consequent greening of the perianth, depend on the penetration of the pollen tube; but whether the stimulus is mechanical or chemical does not appear.

The prompt fading of the flowers, possible after an insect bite on the stigma or after stimulation by foreign pollen, and the small crop of fruit on these tropical orchids, awaken doubts in FITTING'S mind as to the validity of the teleological interpretation of the elaborate mechanisms which are believed to secure cross-pollination. Perhaps they were effective in a past age when insect life was richer, he adds by way of apology for his temerity in suggesting such heresy. He will find this heresy not unwelcome, we imagine, in this country, where ecologists are questioning whether there is even adequate proof that cross-pollination is advantageous.—C. R. B.

Cytology of Oenothera.—GEERTS[23] published an account of embryo-sac development and chromosome reduction in Oenothera. A row of four megaspores is formed, with typical reduction phenomena, the megaspore nearest the micropyle forming the embryo sac. Its nucleus divides only twice. Both

[23] GEERTS, J. M., Beiträge zur Kenntnis der cytologischen Entwicklung von *Oenothera Lamarckiana*. Ber. Deutsch. Bot. Gesells. **26a**:608–614. 1908.

———, Beiträge zur Kenntnis der Cytologie und der partiellen Sterilität von *Oenothera Lamarckiana*. Separate (source unknown). pp. 116. *pls.* 5–22. 1909.

nuclei resulting from the first division remain in the upper portion of the sac. One of these divides to form the two synergids, and the other forms the egg and polar nucleus. There are therefore no antipodals and only one polar nucleus. In fertilization one male nucleus unites with the egg; the other unites with the polar nucleus to form the endosperm.

The account of reduction phenomena confirms, in all the main points, the previous accounts of GATES.[24] There is no fusion of parallel threads in synapsis. The spirem later breaks into the vegetative number of chromosomes, which afterward become paired. The first mitosis separates whole chromosomes, and the second separates the longitudinal halves of these. Certain critical stages during the period between synizesis and diakinesis, which prove that the chromosomes are formed by the segmentation of a single spirem thread, are not represented; but these stages are the most difficult to obtain, probably because they are passed through quickly. It seems now pretty evident that there are two general methods of reduction in plants, as in animals, one involving a telosynapsis, the other a parasynapsis or side-by-side pairing of chromosomes.

The question of sterility is also examined, with interesting results. In *Oenothera Lamarckiana* 50 per cent. of the ovules are found to degenerate, and about 50 per cent. of the pollen grains—two from each tetrad of spores. A large number of other Onagraceae were examined, nearly all of which were found to exhibit more or less sterility. GEERTS concludes that the sterility of *O. Lamarckiana* cannot be explained as the result of hybridization, cultivation, or lack of nutrition or space, but that it has been inherited from a remote ancestor, probably from the ancestor of the whole sub-family. He thinks that since this sterility is heritable it must have originated by a mutation, or rather two mutations, one on the pollen side and one on the megaspore side, since they are often sterile in different degrees in the same species!

So far from explaining anything, it seems to the reviewer that this muddies the pool and is much worse than a flat confession of ignorance as to the cause. It will be unfortunate if botanists acquire the habit of ascribing the origin of complex conditions, such as sterility, to a sudden "mutation" in some ancestor. There is no evidence to show that the sterility has not been gradually acquired, and for that matter independently acquired, in the different species. To call it a mutation helps to explain neither its origin nor its cause.—R. R. GATES.

Seedlings of conifers.—HILL and FRAINE[25] have published a second paper on the seedlings of gymnosperms, the thesis being that polycotyledony is attained by the splitting of preexisting members, which were probably two in number. In the present investigation seedlings of Tsuga, Abies, Picea, Cedrus, Pinus, Larix, Pseudolarix, and Araucaria were studied. The general result shows that

[24] GATES, R. R., A study of reduction in *Oenothera rubrinervis*. BOT. GAZETTE **46**:1–34. *pls. 1–3.* 1908.

[25] HILL, T. G., AND DE FRAINE, E., On the seedling structure of gymnosperms. Annals of Botany **23**:189–227. *pl. 15. figs. 11.* 1909.

the Taxineae, Podocarpineae, and many Cupressineae have two cotyledons, and that each cotyledon (Podocarpineae being excepted) contains one vascular strand and the primary root is diarch. Among the Abietineae, however, in which polycotyledony prevails, each cotyledon has a single vascular strand, but the number of poles of the primary root holds no obvious relation to the number of cotyledons.

In summarizing the evidence of splitting, the authors add the following testimony: the occurrence of partially split cotyledons, the frequent obvious grouping of cotyledons, and the cases of transition. *Pinus contorta Murrayana* may be selected as an illustration of the last case, in which form three entire cotyledons were found, one of them much larger than the other two and containing two entirely distinct vascular strands. The authors speak of this as a case of one whole cotyledon and two half-cotyledons. Trouble of course comes with the higher numbers of cotyledons, and at this point the explanation offered is not clear. It is acknowledged that in some cases an increased number of cotyledons may result from the appearance of extra primordia, which represent the displacement of foliage leaves from the first stem node to the cotyledonary node.

The general summary of facts contains the following items: the occurrence of more or less complete cotyledonary tubes (over 20 species cited); the existence of cases of incomplete splitting (4 species cited); the general presence of cotyledonary resin ducts (several in araucarians, two in 12 species cited, one in 6 species, and none in 6 species or more); the occurrence of 4–8 vascular strands in each cotyledon of Araucaria, and of one strand in the cotyledons of Tsuga, Abies, Picea, Cedrus, Pinus, and Larix; the occurrence of mesarch structure in occasional cotyledons of *Tsuga canadensis*, *Pinus Pinea*, and *P. Gerardiana*.

SHAW[26] has investigated the seedling of *Araucaria Bidwillii*, a tuberous species and one not studied by HILL and FRAINE. He finds that the cotyledonary vascular strands are very numerous and variable (12 to 16), that the poles of the root are equally variable (5 to 7), and that there is a very confused connection between the two. The protoxylem groups of the root are gradually reduced until the diarch condition is finally attained.—J. M. C.

The Piccard rotation experiments.—HABERLANDT[27] has repeated PICCARD'S rotation experiments,[28] for which he used the seedlings of *Vicia Faba*, *Lupinus albus*, and *Phaseolus multiflorus*. He characterizes PICCARD'S conception as good, but the execution of the experiments and the interpretation of the results as faulty.

He claims to have eliminated all PICCARD'S technical errors by devising a very substantial and accurate centrifuge, and by securely fastening the seedlings

[26] SHAW, F. J. F., The seedling structure of *Araucaria Bidwillii*. Annals of Botany **23**:321–334. *pl. 21. figs. 6.* 1909.

[27] HABERLANDT, G., Ueber die Verteilung der geotropischen Sensibilität in der Wurzel. Jahrb. Wiss. Bot. **45**:575–600. 1909.

[28] PICCARD, AUGUST, Neue Versuche über die geotropische Sensibilität der Wurzelspitze. Jahrb. Wiss. Bot. **40**:94–102. 1904.

with plaster of Paris, at the same time supplying them with sufficient moisture. The roots were placed at an angle of 45° with the axis, as were PICCARD'S. While PICCARD used 20–40 rotations per second, HABERLANDT found it necessary to use only 5–20.

If the tips of the roots extended 1.5^{mm} or more beyond the axis, they always bent in the direction according with the irritability of the tip; if 1^{mm} or less, the curvature was determined by the irritability of the growing zone. HABERLANDT points out (what he says PICCARD and his critics have failed to notice) that where the root tip extends 1.5^{mm} beyond the axis, the growing zone receives on the average greater stimulation than the root tip, the centrifugal acceleration of the growing region, by reason of its greater length, being 2.8–3.9 times that of the tip. This, of course, is due to the considerable length of the growing zone. HABERLANDT never gets the S curve described by PICCARD. He concludes that 1.5–2^{mm} of the root tip, in the forms worked with, is very sensitive to gravity and to centrifugal acceleration. The growing zone is likewise sensitive, but far less so than the tip. The marked geotropic sensitiveness of the tip corresponds to the well-developed statolith apparatus of the cap, while the slighter sensitiveness of the growing zone is due to the rather poorly developed statolith starch of the periblem in that zone.

He finds that the geotropic irritability of the growing zone is manifested with acclerations as low as 0.25 gravity, and therefore that it comes into play in ordinary geotropic response, exactly opposite to NĚMEC'S conclusion.

HABERLANDT also conducted a set of decapitation experiments, making full allowance for the shock effect of decapitation, which accord fully with the results by the PICCARD method. He concludes that all these results are quite in harmony with the statolith theory.—WM. CROCKER.

Plant proteases.—VINES has now for more than ten years devoted his attention to the proteases of plants and he has made the field practically his own. The conclusions he has from time to time announced mark periods in the development of the problem. The last paper by this author[29] should be considered in two parts, the first of which deals with his latest results, while the second constitutes a review of the earlier investigations, together with final conclusions.

The papain or papayotin of the latex of papaw, which has long been known to digest proteins, was shown by MARTIN to be both peptic and peptolytic. It was therefore designated a tryptic enzyme. The discovery that other vegetable extracts (germinated lupin, castor-bean, some fruit juices, malt, yeast) had a like action, led to the notion that plant proteases in general are tryptic. This conception, although a generalization from too limited data, was an advance, as it supplanted the prevalent idea (also resting upon an insecure foundation) that plant proteases are peptic. Following up his work on tryptic extracts from various sources, VINES has finally come to believe that the proteases of plants are of two sorts, the peptases and the ereptases. This conviction has been further fixed

[29] VINES, S. H., The proteases of plants. VI. Annals of Botany **23**:1–18. 1909.

by his latest results, which are that from papayotin both peptase and ereptase may be obtained. The former is soluble in dilute NaCl and little soluble in distilled water, while the latter is easily soluble in pure water. That the demonstration of these two proteases in papayotin might be more complete is admitted by the author. Similarly, preparations from both fresh and dry yeast show the presence of peptase and ereptase.

The proposal of VINES, after reviewing the subject, to supplant the "vegetable trypsin" idea by the conclusion that the proteases of plants belong to two main groups, the peptases and the ereptases, and his further classification of the former into endopeptases and ectopeptases, appeal to the reviewer as unnecessary and unwarranted, inasmuch as the new may prove to be as incomprehensive as was the "trypsin" idea. Further, if a name must be given to something of which little is known, that name should have some reference to the qualities marking individuality, rather than to the mere incident of its occurrence. So far, the "ectopeptase" is confined to Nepenthes. The anticipation of the author that "ectopeptase" is of wide occurrence may be justified, but in one case, namely, the pitcher-liquid of Sarracenia, peptic action has not been found.[30]—RAYMOND H. POND.

Morphology of Pseudotsuga.—The investigation of the North American representative of this interesting genus by LAWSON[31] has filled a gap in our knowledge. In general it conforms to the well-known characters of Abietineae, but it presents some interesting peculiarities. The pollen grains are wingless, and the mechanism for receiving them is most unusual. There is a stricture of the integument above the nucellus, which results in two distinct micropylar chambers. The outer chamber is partially inclosed by the infolding tip of the integument, from whose inner face numerous hairlike processes are developed as outgrowths from the epidermal cells. Within this chamber the pollen grains are received and germinate, a tangle of tubes passing down through the inner chamber to the nucellus.

At the time of pollination (April–May in California) the pollen grain contains the two disorganized prothallial cells and the generative and tube nuclei. Just before tube-formation the generative cell divides to form the stalk and body cells, both with distinct membranes, but soon becoming very unequal. Before the tip of the nucellus is reached by the tube, the nucleus of the body cell divides to form two unequal male nuclei. Fertilization takes place within 60 days after pollination, and the entire nuclear contents of the tube are discharged into the egg.

The functioning megaspore is surrounded by a distinct tapetal zone, and the magaspore membrane becomes conspicuous. The development of the female

[30] ROBINSON, WINIFRED J., A study of the digestive power of *Sarracenia purpurea*. Torreya **8**:181–194. 1908.

[31] LAWSON, A. A., The gametophytes and embryo of *Pseudotsuga Douglasii*. Annals of Botany **23**:163–180. *pls. 12–14.* 1909.

gametophyte proceeds as usual, filling the sac with primary endosperm cells, in which free nuclear division occurs before cross-walls form the permanent tissue. The archegonia are usually four in number, and a distinct ventral canal cell is cut off, the membrane persisting until fertilization occurs. The proembryo is the usual one of Abietineae, walls appearing at the eight-nucleate stage, and four tiers of cells being organized, the uppermost tier being open.—J. M. C.

Embryo sac of Pandanus.—CAMPBELL[32] has published the details of the development of the embryo sac of this interesting form, the preliminary account having been published last year.[33] The stage showing fertilization was not obtained, so that it is not certain that the fourteen-nucleate condition described is the fertilization stage. The megaspore mother cell is overlaid by several layers of parietal cells, which are thought to be derived from a single cell. The division of the mother cell is followed by the direct production of the embryo sac by the inner daughter cell. At the first division, the two nuclei assume the polar positions, and subsequent divisions result in two micropylar nuclei and twelve antipodal nuclei. If two megaspore nuclei are supposed to enter into the structure of this sac, there is a single division of one of them, and a succession of divisions from the other one. From any point of view, such a sac would be unusual, and the author is inclined to regard it as "a new type with its nearest analogue in Peperomia," a type which is probably more ancient than the prevailing eight-nucleate sac. He dissents from the idea that the reduction division necessarily determines a megaspore in angiosperms, believing that this event may so shift in the life-history that a megaspore may be defined regardless of it. After all, this is merely a matter of definition, and that is a matter of agreement. Shall a megaspore be defined as the product of the two reduction divisions or as the cell which produces the embryo sac? Which definition will have the greater morphological stability?—J. M. C.

Diffusion of CO_2 in leaves.—That CO_2 does not diffuse extensively through the mesophyll has been known for more than thirty years from the researches of MOLL, and experiments to show the localization of photosynthesis have become common in every physiological laboratory. Under MOLL's direction, ZIJLSTRA has investigated the extent of diffusion in leaves of different structures.[34] He finds that in all leaves the CO_2 formed in the leaf itself suffices to produce a line or zone of starch at the edge of the darkened region. In net-veined leaves the movement of CO_2 supplied from the air is prevented by the larger veins which

[32] CAMPBELL, D. H., The embryo sac of Pandanus. Bull. Torr. Bot. Club **36**:205–220. *pls. 16, 17.* 1909.

[33] CAMPBELL, D. H., The embryo sac of Pandanus. Preliminary note. Annals of Botany **22**:330. 1908.

[34] ZIJLSTRA, K., Kohlensäuretransport in Blättern. Proefschrift ter verkrijging aan der graad van Doctor in plant- en dierkunde aan der Rijks-Universiteit te Groningen. . . . . 8vo. pp. 128. *pls. 2. figs. 2.* Groningen: M. de Waal. 1909.

stretch from surface to surface without intercellular spaces. Consequently the width of the lines of starch produced at the edge of the darkened region is not widened even though the unlighted area is supplied with CO_2 under abnormal pressure. If the net be coarse the zone of marginal starch will be wider than if it is fine. Diffusion of self-produced CO_2 to 2.5^{cm} at most is thus possible; for in parallel-veined leaves of Triticum, Hordeum, and Zea, though the veins do not prevent diffusion, the intercellular passages are so narrow as to limit it to 3^{cm}. In Tradescantia and Acorus the transverse anastomoses prevent more extensive movement. In Eichhornia, Pontederia, and Eucomis the leaves have spacious intercellular passages, and so the movement is much more free. But even here the diffusion scarcely surpasses 3^{cm}, unless through a region of the leaf that is not in condition to act on the CO_2. In nature, therefore, movement of CO_2 may be considered practically nil.—C. R. B.

Seedling of a graft-hybrid.—Certain branches of the graft hybrid, *Cytisus Adami*, revert, producing flowers having the characters of the reputed parents *C. Laburnum* and *C. purpureus* respectively. The *C. Adami* flowers are ordinarily sterile, while those borne on reverted branches reproduce their respective parents.

In May, 1904, HILDEBRAND[35] observed that several flowers of a *C. Adami* branch of a cultivated specimen in the Freiburg botanical garden had set seed, and was able to obtain three fruits from them, which had chiefly the characters of *C. Laburnum*, but in certain respects resembled *C. purpureus*. It is not known whether these flowers were self-pollinated, but it is not unlikely that the pollen came from *C. Laburnum* flowers, since the *C. Adami* flowers are usually sterile. Two of the seeds germinated. Both were very similar in character to *C. Laburnum* and in 1907 one of them produced hundreds of flowers, all having the characters of *C. Laburnum*. No conclusions can be drawn regarding the hereditary bearing of these facts, in the absence of a knowledge of the manner of pollination of the flowers and the nature of the next generation of offspring.—R. R. GATES.

Chlorophyll.—The discussion as to the phosphorus content of chlorophyll waxes warm. STOKLASA replies vigorously[36] to TSWETT'S criticisms[37] and takes issue with WILLSTÄTTER'S results.[38] The question is yet in the stage of polemic

---

[35] HILDEBRAND, FRIEDRICH, Ueber Sämlinge von *Cytisus Adami*. Ber. Deutsch. Bot. Gesells. **26a**:590–595. 1908.

[36] STOKLASA, J., BRALIK, V., UND ERNST, A., Zur Frage des Phosphorgehaltes des Chlorophylls. Ber. Deutsch. Bot. Gesells. **27**:10–20. 1909.

[37] TSWETT, M., Ist der Phosphor an dem Anbau des Chlorophylline beteiligt? *Ibid.* **26a**:214–220. 1908.

[38] WILLSTÄTTER, R., Zur Kenntniss der Zusammensetzung des Chlorophylls. Liebig's Annalen der Chemie **350**:48–82. 1906.

WILLSTÄTTER, R., UND BENZ, M., Ueber krystallisiertes Chlorophyll. *Ibid.* **358**: 267–287. 1907.

discussion and will doubtless require further and most careful work. STOKLASA is particularly emphatic, declaring that "we have determined—not only I, but my collaborators, at different times—by definite researches, which we are ready to repeat in any forum, that preparations of chlorophyll all actually contain phosphorus." And again: "Our new investigations, carried out in my laboratory both on crude and pure chlorophyll, prove that the phosphorus is bound up in the chlorophyll complex and does not occur in ionic form. We have recognized with complete certainty glycerophosphoric acid and cholin. Consequently the assertion of EULER and of SCHULZE, that the chlorolecithin hypothesis is finally refuted by WILLSTÄTTER's work, is at least premature."—C. R. B.

The "germination" of Gnetum.—HILL, in studying *Gnetum Gnemon*,[39] finds that the root and hypocotyledonary axis soon escape from the seed coats, leaving behind, in close connection with the reserve food, a foot or sucker. The cotyledons are at first small, but later enlarge somewhat and do photosynthetic work. An older specimen shows the pronounced rodlike foot in the center of the endosperm. The foot contains vascular tissue.

HILL remarks that the foot develops to a greater extent in Gnetum than in either Tumboa or Ephedra. Comparison with the last genus is certainly astonishing. The reviewer can speak for many of the ephedras of the western world. They do not have a structure in the remotest degree resembling the foot of Gnetum as figured by HILL, nor is there even a rudimentary trace of such a structure.—W. J. G. LAND.

Sex of Sphaerocarpus.—Acting upon a suggestion by STRASBURGER, DOUIN[40] has carefully examined 81 groups of *Sphaerocarpus terrestris*, taken by chance from material collected at Chavannes. He finds that about 75 per cent. clearly show 2 male plants and 2 female arising from the spore tetrad, whose members cohere usually until germination. The others were mainly explicable by non-germination of one or more spores of a single or double tetrad, or the accidental dissociation of the members of a tetrad. Several cases clearly anomalous were found: one group (from 2 tetrads) of 5♂ and 3♀; another of 3♂ and 1♀; and two others, 1♂ and 3♀. He corrects certain earlier misstatements regarding sporelings, and now specifies differences between juveniles of *S. terrestris* and *S. californicus*, which before he declared indistinguishable.—C. R. B.

Necrosis of the grape.—Vines killed by this disease[41] have usually, in the opinion of the owners, "just died," yet the writer regards it as a serious disease causing a large percentage of damage. In one young vineyard of 14 acres it is

[39] HILL, T. G., The germination of *Gnetum Gnemon* L. Jour. Roy. Hort. Soc. **34**:1, 2. 1908.

[40] DOUIN, CH., Nouvelles observation der Sphaerocarpus. Rev. Bryol. **36**:37–41. 1909.

[41] REDDICK, D., Necrosis of the grape vine. Cornell Univ. Agric. Exp. Sta. Bull. 263. Feb. 1909.

estimated 4000 to 5000 vines succumbed. The symptoms are: A trimmed and tied vine that has failed to put out shoots; a vine that has sent forth shoots, the latter dying after a few weeks; shoots and leaves that exhibit dwarfing; blanched and chlorotic leaves; leaves and fruit shriveling and dying in the summer; the presence of fleshy or corky excrescences on the stem, of minute black pimples on a dead spur, or of small reddish-brown spots on the green shoots. The disease is attributed to *Fusicoccum viticolum*, which is described as a new species.—F. L. STEVENS.

Origin of plastids.—Without giving any adequate evidence, even in outline, SCHILLER propounds the idea in a preliminary paper[42] (which can have no other purpose than to secure priority, and this ought to be denied in such cases even if the guess proves correct) that the plastids of plant cells arise by the extrusion and fragmentation of nucleoli, whose fragments subsequently grow and change their structure. He "is inclined to the view" that the plant cell is therefore to be looked upon as binucleate, in the sense that the chromatophores correspond to a macro- or yolk-nucleus, a view which has lately been expressed by MOROFF for animal cells.—C. R. B.

Leaf blight.—STEVENS and HALL describe[43] a disease of apple, pear, and quince, whose prominent symptom suggests the name leaf blight. As it is due to *Hypochnus ochroleucus* Noack, they propose the name hypochnose, in conformity to a scheme for making names of diseases by combining euphonically the name of the fungus with the termination *-ose*. The disease resembles fire-blight (bacillose), but only the leaves are affected (no twigs), and they stand erect instead of drooping. The disease prevails in the mountain section of North Carolina, West Virginia, and Alabama, but is probably much more widespread.—C. R. B.

Geoglossaceae of N. A.—The attention of those interested is directed to an elaborate monograph[44] of this family of Discomycetes, allied to the better-known Helvella and Morchella types, as represented on this continent. There are eleven genera, and the original fifty-three species DURAND reduces to forty-two. We have no competence to review the work critically.—C. R. B.

---

[42] SCHILLER, JOS., Ueber die Entstehung der Plastiden aus dem Zellkern. Oesterr. Bot. Zeits. **59**:89–91. *figs. 3.* 1909.

[43] STEVENS, F. L., AND HALL, J. G., Hypochnose of pomaceous fruits. Ann. Mycol. **7**:49–59. *figs. 8.* 1909.

[44] DURAND, ELIAS J., The Geoglossaceae of North America. Ann. Mycol. **6**:387–477. *pls. 5–22.* 1908.

GENERAL INDEX

Classified entries will be found under Contributors and Reviews. New names and names of new genera, species, and varieties are printed in **bold-face** type; synonyms in *italic*.

A

Abobra, histology of fruit and seed 307
Absidia Orchidis, Lendner on 420
Adansonia, Hochreutiner on 472
African plants 473; Brown and Stapf on 163; Moore on 161; Schinz on 161
Agave virginica, reduction division in 198
Air, Saito on germs in 251
Alfalfa, Stewart et al. on diseases of 343
Algae, mounting of 237
Alternaria **Dianthi** 413
Alternariose, carnation 409
Alternation, Lang on ontogenetic theory of 477
America, plants of tropical 472
Amitosis in Synchytrium 136
Amphiachyris Fremontia **spinosa** 431
Anatomy of, fruits and seeds of Cucurbitaceae 263; Isoetes 301; Microcycas calocoma 127; Saxegothaea, Stiles on 251
Androstachys 473
Apocynaceae, Wildeman on 163
Aquatics, François on 167
Aragallus, barium and loco 344
Aralia nudicaulis, homoeosis in 50
Araucaria, Shaw on seedling of 481
Argemone, Green on 472
Aristogeitonia 473
Asterococcus, Scherffel on 473
Astragalus, barium and loco 344; Bornmüller on 473
Aspidium acrostichoides, homoeosis in 46
Ataenidia, Gagnepain on 472
Athyrium, Copeland on 164; Filix-foemina, homoeosis in 43
Atkinson, George F. 79
Australian plants, Maiden and Betche on 163
Avena, Blaauw on phototropism in 343
Azotobacter, Krzemieniewski on nitrogen fixation by 475

B

Blaauw, A. H., work of 343
Bacillariaceae, Schroeder on 163
Bagnisia, Cheeseman on 163
Bahamas, Britton on flora 473
Baileya, multiradiata 431; **perennis** 431
Balls, L. W., work of 247
Barber, K. G. 263
Barium and loco, Crawford on 344
Barnes, C. R. 242, 243, 244, 344, 414, 415, 416, 424, 467, 479, 485, 486, 487, 488
Bateson, work of 469
Beauverd, G., work of 472
Beccari, O., work of 472
Bernard's "Protococcacées et Desmidiacées" 243
Betsche, E., work of 163
Bicknell, E. P., work of 162
Bixaceae, Gagnepain on 472
Blakeslee, A. F. 418
Blight, Stevens and Hall on leaf 488
Bogs, peat deposits in local 445; toxins 389
Boissieu, H. de, work of 163
Bonati, G., work of 162, 472
Bornmüller, J., work of 161, 163, 473
Borntraeger's "Tabulae Botanicae" 160
Brand, A., work of 161
Breeding, East on potato 251
Britton, N. L., work of 162, 472, 473
Brooks, Charles, work of 162
Brown, N. E., work of 163
Buchanan, R. E. 475
Buder, J., work of 170
Burns, G. P. 445
Butea, Prain on 163

C

Calathea, Gagnepain on 472
Calceolaria, Kränzlein on 162
Calochortus, **comosus** 425; flexuosus 425
Calorimeter, respiration 72
Cankers of Rhododendron, von Schrenk on 252
Capparidaceae, Gagnepain on 162; graft-hybrids 84
Carbon dioxid in leaves, Zijlstra on diffusion of 485
Carex, Bicknell on 162
Carnation alternariose 409
Carnegiea, Britton and Rose on 472
Carya, Donde on 163

Castle, W. E., work of 471
Cattleya labiata, homoeosis of 44
Centaurea, Gugler on 163
Centradeniastrum, Urban on 162
Central America, plants of 253
Ceratozamia, extrafascicular cambium 149
Chabert, Alfred, work of 162
Chaenactis, attenuata 434; carpoclinia 434; **paleolifera** 434
Chamberlain, Charles J. 172, 215
Cheeseman, T. F., work of 163
China, plants of, Dunn on 162; Komarov on 161
Chipp, T. F., work of 162
Chlorophyll, Stoklasa on 486; Tswett on 486; Willstätter on 486
Chomelia **brachypoda** 255; filipedis 255
Christ, H., work of 163
Chromogens, Tammes on 341
Chrysler, M. A. 169, 171, 337; work of 172
Chylisma **hirta** 428
Circinella, Lendner on 420
Cirsium, Petrak on 162
Cistus, Coste on 163
Citrullus, histology of fruit and seed 292
Cleistogamy in Linaria 454
Clematoclethra, Komarov on 161
Codonopsis, Chipp on 162; Komarov on 161
Colorado, Crataegus in 72
Compannia, Chabert on 162
Condalia, **divaricata** 427; lycioides 427
Conifers, Chrysler on tyloses in 172; seedlings, Hill and Fraine on 248, 481
Contributors: Atkinson, G. F. 79; Barber, K. G. 263; Barnes, C. R. 242, 243, 244, 344, 414, 415, 416, 424, 467, 479, 485, 486, 487, 488; Blakeslee, A. F. 418; Buchanan, R. E. 475; Burns, G. P. 445; Chamberlain, C. J. 172, 215; Chrysler, M. A. 169, 171, 337; Copeland, W. F. 9; Coulter, J. M. 156, 159, 170, 172, 244, 251, 477, 478, 481, 484, 485; Cowles, H. C. 73, 74, 81, 159, 170, 252; Crocker, W. 69, 82, 164, 170, 249, 252, 339, 340, 341, 342, 343, 344, 482; Dachnowski, A. 389; DeVries, H. 1; Dorety, Helen A. 152, 248; Gates, R. R. 79, 83, 84, 154, 168, 169, 246, 250, 251, 473, 476, 480, 486; Greenman, J. M. 153, 157, 158, 161, 162, 338, 339, 467, 472; Griggs, R. F. 136; Harris, J. A. 438; Hefferan, Mary 75, 76, 251; Hill, E. J. 454; Holm, T. 167; Jeffrey, E. C. 424; Land, W. J. G. 487; Leavitt, R. G. 30; Lindau, G. 241; Nelson, A. 425; Nieuwland, J. A. 237; Olsson-Seffer, P. 85; Osterhout, W. J. V. 148; Peirce, G. J. 72; Perkins, J. 239; Pond, R. H. 247, 473; Ramaley, F. 72; Reed, H. S. 355; Saxton, W. T. 406; Schreiner, Oswald 355; Shull, G. H. 337; 468; Smith, J. D. 253; Stevens, F. L. 172, 343, 409, 487; Stokey, Alma G. 311; Thomson, R. B. 26, 345; Westerdijk, Johanna 241; Yamanouchi, S. 173
Convolvulus, House on 161
Copeland, E. B., work of 164
Copeland, W. F. 9
Cornus, Wangerin on 472
Correlations, East on 168
Correns, C., work of 468
Coste, H., work of 163
Cotylonychia 162
Coulter, John M. 156, 159, 170, 172, 244, 251, 477, 478, 481, 484, 485
Cowles, Henry C. 73, 74, 81, 159, 170, 252
Crataegus in Colorado 72; Sargent on 163
Crescentia 259
Crocker, William 69, 82, 164, 170, 249, 252, 339, 340, 341, 342, 343, 344, 482
Crocus sativus, homoeosis in 40
Crucianella, Malinowski on 161
Cryptanthopsis, Ule on 473
Cucumber, histology of fruit and seed 283
Cunninghamella elegans, Lendner on 420; Jeffrey on 171
Cucurbitaceae, histology of fruit and seed 263
Cucumis, histology of fruit and seed 287
Cylindrosporium, Brooks on 162
Cyperaceae, Palla on 162
Cytology, Agave 198; as a basis for Mendelism, Grégoire on 80; of Fucus 173; of Oenothera, Geerts on 480

D

Dachnowski, Alfred 389
Daucus, Carota, homoeosis in 51
Dauphin, Jean, work of 422
Davidson, A., work of 163
DeVries, Hugo, see Vries, H. de
Diatoms, Mangin on membrane 424
Dicksonia punctilobula, homoeosis in 48
Diseases, of Dianthus caryophyllus 409; Stewart and Hodgkiss on plant 172
Dioon edule, spermatogenesis in 215
Dipsacan, Tammes on 341
Doncaster, L., work of 469
Donde, L. A., work of 163
Dop, P., work of 163
Dorety, Helen A. 152, 248
Douin, Ch., work of 487
Drosera intermedia, homoeosis in 40
Drude, see Engler

Drygalski's "Deutsche Südpolar-Expedition" 244
Ducamp's "Du colibacille et du bacille typhique" 76
Dunn, S. T., work of 162
Durand, E. J., work of 488
Durham, F. M., work of 470
Dysodia, cancellata 435; Cooperi 434, 435; **cupulata** 435; **fusca** 436; pappposa 434; porophylla 435; porophylloides 435; speciosa 435; **Thurberi** 436

E

Earle, F. S., work of 473
East, E. M., work of 168
Echinocystis, histology of fruit and seed 300
Ecology of sea shores 85
Edaphic factors and vegetation 94
Elmer, A. D. E., work of 161
Embryo sac of Pandanus, Campbell on 485
Encelia, nudicaulis 433; nutans 433
Enceliopsis 432; **grandiflora** 433; **nudicaulis** 433; **nutans** 433; **tuta** 433
Engler, "Das Pflanzenreich" 157; and Drude's "Vegetation der Erde" 73; and Prantl's "Natürlichen Pflanzenfamilien" 161
Enzymes, Grüss on 339; oxidizing 376
Epimedium, Komarov on 161
Equisetales, Halle on Mesozoic 424
Errera, "Recueil d'œuvres de" 417
Eriocaulon, Beauverd on 472; Lecomte on 162
Ernst, A., work of 249
Eryngium, Wolff on 472
Euphorbia, Bornmüller on 161; **adinophylla** 261; crenulata 437; manca 437; Nortoniana 437; Schlechtendalii 261
Evans, A. W., work of 163; Nicholas's "Bryophytes of Connecticut" 159
Evaporation, influence on vegetation 90
Ewart, A. J., work of 69
Excretions, Stoklasa and Ernst on root 249
Extracts, soil, oxidation in 371
Eylesia, Moore on 161

F

Fawcett, W., work of 473
Ferdinandsen, C., work of 472
Ferns, Copeland on 164; Kirsch and McNichol on tyloses in 169; mutation in the Pierson 32; Rosenstock on 472
Fiebrigiella, Urban on 162
Finet, E. A., work of 162
Fitting, H., work of 479
Fischer, E., work of 76
Fluri, Max, work of 252
Foslie's "Lithothamnien" 244
Fraine, E., work of 248
François, L., work of 167
French, G. T., work of 343
Freycinetia, Merrill on 164
Fries, R., work of 164
Fritillaria, Davidson on 163
Fruit of Cucurbitaceae, comparative histology of 263
Fucus, mitosis in 173
Fungi, Ferdinandsen and Winge on 472; Peck on 163; pure cultures of 241; subterranean 75

G

Gagnepain, G., work of 162, 163, 472
Gaillardia **pedunculata** 432
Ganong's "Laboratory course in plant physiology" 242
Gates, R. R. 79, 83, 84, 154, 168, 169, 246, 250, 251, 473, 476, 480, 486
Gaurella, **canescens** 437; *guttulata* 437
Geerts, J. M., work of 480
Gemmation, nuclear in Synchytrium 129
Gentiana crinita, homoeosis in 39
Geoglossaceae of North America, Durand on 488
Geopora, Fischer on 78
Geotropism, Buder on 170; Haberlandt on 482
Germination, of Gnetum, Hill on 487; and light, Heinricher on 164; Kinzel on 164, 341; of Rhinanthaceae, Sperlich on 340
Germs in the air, Saito on 251
Gill fungi, Earle on 473
Gleditsia triacanthos, homoeosis in 49
Gnetum, Hill on germination of 487
Gonolobus, araneosus 257; **patalensis** 256
Gooddingianae, plantae 425
Graft-hybrid 84; Hildebrand on seedling of 486; of Solanum, Winkler on 250
Grape, Reddick on necrosis of 487
Grasses, Hackel on 472
Graves, A. H., work of 478
Gray's "New manual of botany" 153
Greene, E. L., work of 472, 473
Greenman, J. M. 153, 157, 158, 161, 162, 338, 339, 467, 472
Grégoire, V., work of 79
Griffiths, D., work of 163
Griggs, Robert F. 136
Grossweilera, Moore on 161
Growth and temperature, Ball on 247
Grüss, J., work of 339
Guatemala, plants of 253
Guettarda, **cobanensis** 255; crispiflora 255

Gugler, W., work of 163
Guraniopsis, Urban on 162
Guzmania bracteosa 262
Gymnosporangium, Kern on 162

H

Habernaria quinqueseta, homoeosis in 58
Haberlandt, H., work of 482
Hackel, E., work of 162, 472
Hagem, Oscar, work of 418
Hanausek's "Microscopy of technical products" 416
Hard's "The mushroom" 414
Harris, J. Arthur 438
Hayata's "Flora montana Formosae" 158
Heat, factor in cleistogamy 463
Heating of leaves, Wiesner on 344
Hefferan, Mary 75, 76, 251
Heinricher, E., work of 164
Helianthella, argophylla 433; Covillei 433; nudicaulis 433
Hemandradenia 162
Hennings, Paul 239
Hepaticae, Evans on 163; Stephani on 161, 163
Heptocarpum, Ule on 473
Herbarium, Rocky Mountain 425
Hesperonia *glutinosa* 425
Heteroschizis, in Synchytrium 140
Hiern, W. P., work of 161
Hieracium, flagellare, homoeosis in 61; Johansson on 164
Hildebrand, F., work of 486
Hill, E. J. 454
Hill, T. G., work of 248, 481, 487
Histology of fruit and seed of Cucurbitaceae 263
Hochreutiner, B. P. G., work of 472; "Sertum Madagascariense" 338
Hodgkiss, R. E., work of 172
Hoffmannia **Tuerckheimii** 254
Holm, Theo. 167
Homoeosis, crab claw showing 38; in plants, principles of 30
Hooker, J. D., work of 161
House, H. D., work of 161
Humus, development on sea benches 111
Huron River valley, botanical survey of 445
Hus, H., work of 252
Huthia, Urban on 162
Hybrids, graft- 84; Hildebrand on seedling of graft- 486; of Oenothera, DeVries on 473; quadruple 8; Tischler on sterility in 246; triple 1; Winkler on graft- 250
Hydrocotyle umbellata, homoeosis in 51
Hydrometeoric condition, influence on vegetation 90
Hymenatherum Thurberi 436
Hymenoclea fasciculata 431; **patula** 431

I

Impatiens, Hooker on 161
Inheritance of sex, Bateson and Punnett on 468; Castle on 471; Correns on 468; Doncaster and Raynor on 468; Durham on 471; Marryat on 470
Isoetes, anatomy of 311
Isolation and mutation, Leavitt on 170
Itatiaia, Ule on 473

J

Janssonius's "Mikrographie des Holzes" 416
Jasminum officinale, homoeosis in 50
Jeffrey, E. C. 424; work of 171
Johansson, K., work of 164
Justicia **multicaulis** 259

K

Kern, F. D., work of 162
Kinzel, W., work of 164, 341
Kirsch, Simon, work of 169
Koehne, E., work of 473
Komarov, V. L., work of 161
Kränzlein, F., work of 162, 472
Krzemieniewski, S., work of 475

L

Land, W. J. G. 487
Lang, W. H., work of 477
Latency, Shull on 82
Lauraceae, Elmer on 161
Lavauxia **lobata** 429
Lawson, A. A., work of 484
Leaf, anatomy of Isoetes 316; blight, Stevens and Hall on 488; of Podophyllum 438
Leandra, strigilliflora 254; **Tuerckheimii** 254
Leavitt, R. G. 30; work of 170
Lebetina 435; cancellata 435; **Cooperi** 435; **porophylla** 435; **porophylloides** 435; **speciosa** 435
Lecomte, Henry, work of 162
Lendner, A., work of 419
Lepidium pubescens, Thellung on 472
Lesdain, B. de, work of 163
Lesquerella **tenella** 426
Léveillé, H., work of 162, 163
Lichens, Lesdain on 163
Light, factor in cleistogamy 463; influence on vegetation 90; Hildebrand and Kinzel on germination and 164, 341
Linaria, pollination in 454

Lindau, G. 241
Linum **leptopoda** 426
Loco, Crawford on barium and 344
Luffa, histology of fruit and seed 305
Lutz, Anne M., work of 475
Lycopodium Selago, homoeosis in 61
Lythraceae, Koehne on 473

M

Magnolia **gautemalensis** 253; portoricensis 253
Maiden, J. H., work of 163
Maize, Shull on 169
Malinowski, Edmond, work of 161
Malpighiaceae, Dop on 163
Malvales, Fries on 164
Mangin, L., work of 424
Marila, macrophylla 254; **verapazensis** 253
Marryat, D. C. E., work of 470
Mastigobryum, Stephani on 472
Mattei, G. E., work of 163
Mazus, Bonati on 161
McNichols, M., work of 169
Melon, musk, histology of fruit and seed 287; water, histology of fruit and seed 292
Melothria, histology of fruit and seed 308
Mendelism, Grégoire on cytological basis of 79
Mentzelia, **polita** 427; **synandra** 428
Merinthopodium, **campanulatum** 257; neuranthe 257
Merrill, E. D., work of 164
Microcachrys, megasporophyll of 345; tetragona, pollen of 26
Microcycas calocoma, vascular anatomy of 127
Mirabilis **glutinosa** 426
Mitosis, in Fucus 173; Oes on solutions of 172
Moisture of air, influence on vegetation 90
Molisch's "Purpurbacterien" 75
Moore, Spencer le M., work of 161
Morphology of Hypogaeae, Fischer on 76
Mortierella, Dauphin on 422
Mortonia, scabrella *utahensis* 427; **utahensis** 427
Mosses, Paris on 472
Mounting of algae 237
Mucilage ducts in Pipereae 167
Mucor, papers on 418
Mucuna, Léveillé on 162
Mutability and variability in Oenothera 476
Mutant, a vegetative 30
Mutation and isolation, Leavitt on 170
Myrmecocystis, Fischer on 77
Myrmecophily, Nieuwenhuis-Uexküll on 81

N

Nadson, G. A., work of 472
Nakai, T., work of 162
Necrosis of the grape, Reddick on 487
Nectaries, Nieuwenhuis-Uexküll on extrafloral 81
Nelson, Aven 425
Neocalamites, Halle on 424
Neotuerckheimia 258; **megalophylla** 258; **gonoclada** 259
Nephrodium molle, homoeosis in 42
Nicholas, see Evans
Nieuwenhuis-Uexküll, work of 81
Nieuwland, J. A. 237
Nitraria, Komarov on 161
Nitrogen fixation by Azotobacter, Krzemieniewski on 475
Norwegian mucors, Hagem on 418
Nothoscordum, Beauverd on 472

O

Oaks, Merrill on 164
Oes, Adolf, work of 172
Oenothera, canescens 437; Geerts on cytology of 480; DeVries on hybrids of 1, 473; mutability and variability 476
Oliver, F. W., work of 244
Olsson-Seffer, Pehr 85
Opuntia, Griffiths on 163
Orchidaceae, Fawcett and Rendle on 473; Kränzlein on 472
Orchid, flowers and formative stimuli, Fitting on 479; Finet on 162; Rolfe on 163
Osmosis in root hairs, Hill on 170
Osmunda cinnamomea, homoeosis in pinna 48
Osterhout, W. J. V. 148; work of 344
Oxalis, Hus on virescence in 252
Oxidation by roots 355

P

Pachylophus **cylindrocarpus** 429
Palladin, W., work of 83
Palla, Ed., work of 162
Palms, Beccari on 472
Pandanus, Campbell on embryo sac o 485
Paris, E. G., work of 472
Parthenogenesis in Pinus pinaster 406
Peat deposits in local bogs 445
Peck, C. H., work of 163
Peckolt's "Volksbenennungen der brasilianischen Pflanzen" 244
Pedicularis, Bonati on 162

Peirce, George J. 72
Pelargonium, homoeosis in 51
Periodicity in Spirogyra 9
Perkins, J. 239
Permeability, Ruhland on 342
Petrak, F., work of 162
Phalaris, Hackel on 162
Philippine ferns, Christ on 164
Phototropism, Blaauw on 343
Phyllonoma ruscifolia, homoeosis in 59
Physalis crassifolia 431; **genucaulis** 430; muriculata 431
Physostoma elegans, Oliver on 245
Piccard, Haberlandt on rotation experiments 482
Pierson fern, mutation in 32
Pinus pinaster, parthenogenesis in 406
Pipereae, van Tieghem on 167
Pittier, H., work of 162, 472
Pittosporaceae, Gagnepain on 472
Platanthera viridis, abnormal flower of 36
Plastids, Schiller on origin of 488
Podophyllum, leaves of 438
Pollen of Microcachrys tetragona 26
Pollination in Linaria 454
Polygonaceae, Nakai on 162
Polystichum, acrostichoides, homoeosis in 46; angulare, homoeosis in 43; Braunii, homoeosis in pinna 47
Pond, Raymond H. 247, 483
Potato, breeding, East on 251; Stewart et al. on spraying 343
Prain, D., work of 163
Prantl, see Engler
Proteases, Vines on plant 483
Pseudoabutilon, Fries on 164
Pseudobalsamia, Fischer on 78
Pseudotragia, Schinz on 161
Pseudotsuga, Lawson on morphology of 484
Pueraria, Léveillé on 163
Pumpkin, histology of fruit and seed 273
Punnett, R. C., work of 469

Q

Quincula, **lepidota** 430; lobata 430

R

Radermachera, Merrill on 164
Ramaley, Francis 72
Ranales, Worsdell on 171
Ranunculus bulbosus 41
Reaumuria, Bornmüller on 163
Reddick, D., work of 487
Reduction division in Agave 198
Reed, Howard S. 355
Reiche's "Pflanzenverbreitung in Chile" 73
Reinbold's "Meeresalgen" 244
Rendle, A. B., work of 473
"Report of American Breeders' Association" 337
Reproduction, Freund on stimuli 342
Respiration, calorimeter 72; chromogens and 83
Reviews: Bernard's "Protococcacées et Desmidiacées" 243; Borntraeger's "Tabulae Botanicae" 160; DeVries's "Naar Californie II" 159; Drude, see Engler; Drygalski's "Deutsche Südpolar-Expedition" 244; Ducamp's "Du colibacille et du bacille typhique" 76; Engler's "Das Pflanzenreich" 157; Engler and Drude's "Vegetation der Erde" 73; Engler and Prantl's "Natürlichen Pflanzenfamilien" 161; Errera's "Recueil d'œuvres" 417; Evans and Nicholas's "Bryophytes of Connecticut" 159; Fernald, see Robinson; Foslie's "Lithothamnien" 244; Ganong's "Laboratory course in plant physiology" 242; Gray's "New manual of botany" 153; Hanausek's "Microscopy of technical products" 416; Hard's "The mushroom" 414; Hayata's "Flora montana Formosae" 158; Hochreutiner's "Sertum Madagascariense" 338; Molisch's "Purpurbacterien" 75; Peckolt's "Volksbenennungen der brasilianischen Pflanzen" 244; Prantl, see Engler; Reiche's "Pflanzenverbreitung in Chile" 73; Reinbold's "Die Meeresalgen" 244; "Report of American Breeders' Association" 337; Robinson and Fernald's "Gray's new manual of botany" 153; Rydberg's "Rosaceae" 339; Schiffner's "Ergebnisse der botanischen Expedition nach Südbrasilien" 467; Schneider's "Handbuch der Laubholzkunde" 415; Simroth's "Pendulationstheorie" 74; Smith's "Guide to Sowerby's models of British Fungi" 161; Smith's "Synopsis of British Basidiomycetes" 160; Tansley's "Evolution of filicinean vascular system" 336; Thaxter's "Laboulbeniaceae" 156; Thomson's "Heredity" 154; Thonner's "Die Blütenpflanzen Afrikas" 157; Ward's "Trees" 415; Wettstein's "Ergebnisse der botanischen Expedition nach Südbrasilien" 467; Winton's Hanausek's "Microscopy of technical products" 416
Rhinanthaceae, Sperlich on germination of 340
Rhizopus nigricans, Sumstine on 423
Rhododendron, von Schrenk on cankers of 252

Rhodosphaerium diffluens, Nadson on 472
Robertson, T. B., work of 342
Robinson and Fernald's "Gray's new manual of botany" 153
Rocky Mountain plants 425
Rolfe, R. A., work of 163
Root, anatomy of Isoetes 315; excretions, Stoklasa and Ernst on 249; hairs, Hill on osmotic properties of 170; oxidizing power of 355
Rose, J. N., work of 472
Rosenstock, E., work of 472
Ruhland, W., work of 342
Ruppia, Graves on morphology of 478
Ruprechtia, **colorata** 260; Cumingii 261; Deamii 260; fusca 261; **Kellermanii** 260
Rydberg's "Rosaceae" 339

S

Sagittaria, Hiern on 161
Salts of aluminum, Fluri on 252
Sand, influence on vegetation 101, 102
Sapium, Pittier on 162
Sargent, C. S., work of 163
Satyria **meiantha** 256
Saxegothaea, megasporophylls of 345; Stiles on anatomy of 251
Saxton, W. T. 406
Scallop, histology of fruit and seed 281
Schaffner, John H. 198
Scherffel, A., work of 473
Schiffner's "Ergebnisse der botanischen Expedition nach Südbrasilien" 467
Schiller, Jos., work of 488
Schinz, Hans, work of 161
Schneider's "Handbuch der Laubholzkunde" 415
Schreiner, Oswald 355
Schroeder, B., work of 163
Scolopendrium, homoeosis of 44
Scrophulariaceae, Bonati on 472
Seedling, of Araucaria, Shaw on 481; of conifers, Hill and Fraine on 248, 481; of a graft-hybrid, Hildebrand on 486
Seeds, of Cucurbitaceae, comparative histology of 263; Heinricher on germination and light 164; Ewart on longevity 69, 339; Kinzel on germination and light 164, 341; longevity of 69; Oliver on primitive 244; of Rhinanthaceae, Sperlich on germination 340
Selenipedium caudatum, homoeosis in 40
Sennen, F., work of 164
Sex, inheritance of, Bateson and Punnett on 468; Castle on 471; Correns on 468; Doncaster and Raynor on 468; Durham on 470; Marryat on 470; of Sphaerocarpus, Douin on 487
Shaw, F. J. F., work of 482
Shreve, Forrest, work of 252
Shull, George H. 337, 468; work of 82, 169
Sicyos, histology of fruit and seed 296
Simroth's "Pendulationstheorie" 74
Sincoraea, Ule on 473
Sirrine, F. A., work of 343
Smith's "Guide to Sowerby's models of British Fungi" 161; "Synopsis of British Basidiomycetes" 160
Smith, John Donnell 253
Soils, effect of bog toxins upon 389; extracts, oxidation in 371; and vegetation, relation of on sandy shores 85
Solanaceae, Winkler on graft hybrids 84, 250
Solutions, Osterhout on balanced 148, 344
Somali land plants, Mattei on 163
South American plants, Urban on 162
Spanish plants, Sennen on 164
Sperlich, A., work of 340
Spermatogenesis in Dioon edule 215
Sphaerocarpus, Douin on sex of 487
Spiranthes cernua, homoeosis in 59
Spirogyra, calospora 16; catenaeformis 18; dubia 19; Fluri on 252; Hantzschii 17; inflata 16; Jurgensii 18; longata 18; Lutetiana 19; mirabilis 17; orthospira 19; periodicity in 9; quadrata 16; varians 18
Squash, histology of fruit and seed, crooknecked 279; winter 282
Stapf, O., work of 163
Statolith theory, Buder on 170
Stem, anatomy of Isoetes 320
Stephani, F., work of 161, 163, 472
Sterility in hybrids, Tischler on 246
Stevens, F. L. 172, 343, 409, 487
Stewart, F. C., work of 172, 343
Stiles, W., work of 251
Stimuli, Fitting on formative 479; to reproduction, Freund on 342
Stokey, Alma G. 311
Stoklasa, J., work of 249, 486
Storage, Shreve on transpiration and water 252
Sumstine, D. R., work of 424
Symplocaceae, Brand on 161
Synchytrium, amitosis in 136
Swiss mucors, Lendner on 419
Swynnertonia, Moore on 161

T

Tammes, Tine, work of 341
Tansley's "Evolution of filicinean vascular system" 336

Taxonomy 161, 472
Temperature, and growth, Balls on 247; influence on vegetation 86, 95
Thaxter's "Laboulbeniaceae" 156
Thellung, A., work of 472
Thomson, Robert B. 26, 345; J. Arthur, "Heredity" 154
Thonner's "Die Blütenpflanzen Afrikas" 157
Tischler, G., work of 246
Topography, influence on vegetation 111
Toxins, bog 389; effect on oxidation 384
Tracheids, of conifers, Chrysler on 172; in Cunninghamia 171
Transpiration, influence on vegetation 90; and water storage, Shreve on 252
Trichosanthes, histology of fruit and seed 309
Tswett, M., work of 486
Tropaeolum, Wagner on 164
Tulbaghia, Beauverd on 472
Tyloses, in ferns, Kirsch on 169; McNichol on 169; in tracheids of conifers 172

U

Ule, E., work of 473
Urban, I., work of 162
Uropedium Lindenii, homoeosis in 40

V

Van Tieghem, P., work of 167
Variability in Oenothera 476
Vascular system of Ranales 171
Vegetation and soil on sandy sea shores 85
Violaceae, Boissieu on 163
Vines, S. H., work of 483
Virescence in Oxalis, Hus on 252
Von Schrenk, H., work of 252
Vries, Hugo de 1; "Naar Californie II" 159; work of 473

W

Wagner, R., work of 164
Wangerin, W., work of 472
Ward's "Trees" 415
Welwitschia, Pearson on 166
Westerdijk, Johanna 241
West Indian plants, Britton on 162; U. S. plants, Greene on 473
Wettstein's "Ergebnisse der botanischen Expedition nach Südbrasilien" 467
Wiesner, J., work of 344
Wildeman, E. de, work of 163
Willstätter, R., work of 486
Wilson, J. K., work of 343
Winge, O., work of 472
Winkler, Hans, work of 250
Winton's Hanausek's "Microscopy of technical products" 416
Wisniewski, P., work of 421
Wissadula, Fries on 164
Wolff, work of 472
Worsdell, W. C., work of 171

Y

Yamanouchi, Shigéo 173

Z

Zingiberaceae, Gagnepain on 163, 472
Zygorhynchus Moelleri, Wisniewski on 421